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U.S. Coast Guard Radionavigation System User Survey

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U.S. Department of Transportation
Research and Special Programs Administration
Transportation Systems Center
Cambridge, MA 02142

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16. Abstract

This report documents the findings of a national mail survey of civilian marine and terrestrial users of federally-operated Radionavigation Systems (RNS). The main objectives of the survey were to gather empirical data on the use pattern of current RNSs and on user predisposition towards proposed satellite-based systems. Three populations were targeted: owners of boats 26 feet and above length overall, U.S. parent companies owning U.S. or foreign flagged vessels and U.S. terrestrial surveyors and mappers. The survey was conducted in 1988 on behalf of U.S. Coast Guard by the Transportation Systems Center; the overall response rate was 61% of the total sample. Nearly half the boaters have no need for RNS to navigate. Others use LORAN-C primarily. All merchant vessels use RNSs but rely primarily on Transit. The terrestrial operators are by far the largest percentage users of Global Positioning System (GPS). Omega is the least used RNS among all three survey groups. Higher accuracy of GPS far exceeds boaters' requirements, is about sufficient for the merchant operators' requirements, but falls short of terrestrial operators' requirements. For any current system, a maximum transition of four years is acceptable to half the operators in all three groups surveyed. The annual fuel and time savings attributed to the users of RNSs are negligible for boaters and not substantial for merchant vessel operators relative to their operations. Only one-third of GPS users among terrestrial operators report some fuel savings and four-fifths claim some time savings.

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PREFACE

The USCG survey of radionavigation system users has benefited from the counsel and assistance of a number of persons.

The study was initially directed by Dr. Alexander D. Blumenstiel of the U.S. Transportation Systems Center. Under his supervision, the Radionavigation Users Survey; Supporting Statement for OMB Review was prepared by Input Output Computer Services, Inc. 400 Totten Pond Road, Waltham, MA 02254. Dr. Blumenstiel oversaw this document through several iterations until it was finally approved by U.S. Office of Management and Budget (OMB) in September 1987. After its approval, he gave freely of his time throughout the execution of the survey as a consultant. Finally, Dr. Blumenstiel reviewed the draft report and provided valuable comments.

As the sponsor of the survey, the USCG provided much of the technical input needed in the design of the survey. Lt. Adeste E. Fuentes, the task manager at the Coast Guard Headquarters, assisted in the drafting of the Supporting Statement for OMB Review and the instruments of the survey. His contribution to the survey was immense, without which the survey might not have been as successful. Ltjg. Jimmy C. Robinson, who subsequently took over the responsibilities as task manager, provided a great deal of technical support in interpreting responses on several key questions in the questionnaire.

Finally, the person who officially shouldered the responsibility, as the Division Chief, of seeing the survey through from the initial proposal to the final report is Mr. Edward A. Spitzer of the U.S. Transportation Systems Center. His encouragement and support throughout the project were critical to its success. He was most generous with his time and counsel in all phases.

METRIC / ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectares (he) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gr)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

$[(x - 32)(5/9)]$ °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 hectare (he) = 10,000 square meters (m^2) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gr) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

$[(9/5)y + 32]$ °C = x °F

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES: 0 1 2 3 4 5 6 7 8 9 10

CENTIMETERS: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 25.40

QUICK FAHRENHEIT-CELCIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and/or other conversion factors, see NBS Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10 286.

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EXECUTIVE SUMMARY

To gather empirical data on the civilian use of the Federally-operated radionavigation systems (RNS) and on user predisposition towards proposed satellite-based systems, the United States Coast Guard (USCG) through the United States Transportation Systems Center launched a national survey of radionavigation system users in October 1987. The survey targeted three populations: owners of boats 26 feet and above in length overall that are registered with the maritime states or documented with the Coast Guard, merchant vessel parent companies operating U.S. owned and U.S. flagged or U.S. owned and foreign flagged ships, and terrestrial operators whose principal(s) are U.S. nationals. The overall response rate was 61% of the total sample.

Nearly half the boaters have no need for RNS to navigate. Others use LORAN-C primarily. All merchant vessels use RNSs, but rely primarily on Transit. The terrestrial operators are by far the largest percentage users of Global Positioning System (GPS). Omega is the least used RNS among all three survey groups.

Higher accuracy of GPS far exceeds boaters' requirements and is about sufficient for the merchant vessel operators' requirements. However, GPS falls short of the terrestrial operators' requirements which are the most stringent.

For any current system, a maximum transition period of four years is acceptable to half the operators in all three groups surveyed.

The annual savings attributed to the use of RNSs are negligible for boaters and even though actual savings are quite significant for merchant vessel operators, they may not be large enough relative to their operations to be of any consequence. Only one-third of GPS users among the terrestrial operators reported some fuel savings and four-fifths claimed some time savings.

About 75% of boaters use their boats for recreational purposes. The average ownership period for a boat is approximately eight years. The level of awareness of GPS and other satellite-based systems and services is very low among boaters. The awareness reflects a general lack of interest in the proposed systems and also a failure on the part of the government to sponsor an educational campaign to familiarize the boaters with GPS.

1. BACKGROUND

The United States Department of Transportation (DOT) has the responsibility under the DOT Act (Public Law 89-670) to ensure safe and efficient operation of the U.S. transportation system. It carries out this responsibility as a provider and regulator of transportation, and, in its former role, as the primary government provider of aids to navigation used by the civil community and of certain systems used by the military. Within the DOT, the USCG has the statutory responsibility to establish, maintain, and operate aids to navigation for safe and efficient marine (and in some cases air) transportation.

Besides the DOT, there are several other federal agencies involved or interested in the operation and maintenance of the aids to navigation: the Department of Defence (DOD), the National Aeronautics and Space Administration (NASA), and the Department of Commerce (DOC). To achieve close coordination among all agencies, a DOD/DOT Interagency Agreement was worked out in April 1979, under which the DOT became the focal agency representing the interests of all civil federal agencies, and DOD the military. Based on this agreement, a Federal Radionavigation Plan (FRP) was first issued in 1980. It has been updated biennially since. It describes areas of authority and responsibility and provides a management structure by which the individual operating agencies can define and meet their radionavigation requirements in a cost effective manner. It is thus the official source of radionavigation policy and planning for the Departments of Defense and Transportation.

Although the USCG has the responsibility to manage aids to navigation, all operations, plans and policies have been based on unsubstantiated data and information, especially for the civilian users. Given the prospect that a new radionavigation system (RNS), the Global Positioning System (GPS), will become fully operational in mid 1990s, the USCG has been faced with making contingency plans for the transition to GPS, including the maintenance of current systems during the transition period or even subsequently.

However, no reliable data on civilian use of RNSs have been available to facilitate making such plans. Against this background, the USCG initiated this study for the creation of baseline data on the civilian use of RNSs.

2. OBJECTIVES OF THE SURVEY

The United States Coast Guard (USCG) through the United States Transportation Systems Center launched a study of RNS users in June 1985. The objectives of the survey were to:

1. Gather empirical data on the federally-operated radionavigation systems which would furnish the USCG the necessary user input for making its recommendations to the Secretary of the United States Department of Transportation on the future mix of systems and services for the maritime and terrestrial users;

2. Assess the incidence of ownership and usage of radionavigation equipment among maritime and terrestrial user populations;

3. Evaluate the quality and benefits of services provided by the government;

4. Determine accuracy requirements in different waters and operations;

5. Gauge the general awareness and predisposition towards the proposed satellite-based systems and services; and

6. Determine user preferences for the transition period from current RNSs to GPS.

The study would take the form of a mail survey of the following groups: recreational boatowners, merchant vessel parent organizations, and terrestrial operators. The study design was approved by the Office of Management and Budget, a requirement under the Paperwork Reduction Act, in September 1987. The survey got underway in May 1988 and was completed in January 1989.

3. DATA ANALYSIS

The survey gathered a vast amount of quantitative and qualitative data on the navigation equipment used, RNSs, and user groups. These data have been processed to generate a set of frequency tables for each survey group. Wherever possible, mean values and corresponding standard errors have also been computed. The findings for each group are reported separately in the following three sections: Section 4 contains findings on the state registered and USCG documented boats, Section 5 on the merchant vessels, and Section 6 on the terrestrial users of RNSs. In each Section, the findings are discussed under the following principal headings: mean characteristics and aggregate projections, current RNSs, proposed RNSs, the receiving system attributes, craft (not applicable to terrestrial operator survey) characteristics, respondent comments, and some concluding remarks.

In Section 7, general conclusions based on the entire survey findings are discussed.

Finally, in Appendix A, the methodology used in this survey is described, and in Appendix B, the questionnaires are reproduced.

4. STATE REGISTERED AND USCG DOCUMENTED BOATS

The questionnaire for the state registered and United States Coast Guard (USCG) documented boat (boat, for short) operators was designed to gather data on: boaters' appraisal of current RNSs, their predisposition towards the proposed more accurate systems, receiver attributes and purchase plans, and boating characteristics. A discussion of these survey findings is preceded by the delineation of mean characteristics signifying typicality and of the receiver population estimates for boats that are 26 feet and above in length overall.

4.1 MEAN CHARACTERISTICS AND RECEIVER POPULATION PROJECTIONS

This section is divided into two parts. Part 4.1.1 contains a discussion of significant mean characteristics and part 4.1.2 receiver population projections.

4.1.1 MEAN CHARACTERISTICS

The mean values computed from the survey data represent the middle position of various data distributions and provide a profile of the typical unit's characteristics. The following statistics show the mean characteristics and corresponding standard errors specified to 95% level of confidence.

Length: 42 feet ± 1 foot
Price Paid: $110,441 ± $24,156
Owned: 7.8 years ± 0.2 year
Period Operated: 8.6 months ± 0.1 month

RNS Usage:[1]	Radiobeacons	Transit	LORAN-C
Open Ocean	21% ± 3%	78% ± 7%	63% ± 4%
Coastal Waters	27% ± 3%	56% ± 12%	64% ± 3%
Inland Waters	16% ± 4%	*	42% ± 3%
Great Lakes	14% ± 4%	*	25% ± 3%
Lakes & Rivers	*	*	13% ± 3%

RNS Problems:[1]	Radiobeacons	Transit	LORAN-C
No Signal	18% ± 2%	*	5% ± 1%
Weak Signal	24% ± 2%	*	8% ± 1%
Interference	16% ± 2%	*	6% ± 1%

Savings Due to RNS:	Radiobeacons	Transit	LORAN-C
Fuel (in gal)	22 ± 7	*	153 ± 13
Time (in hours)	8 ± 2	*	39 ± 4

RNS Transition (in years):	Radiobeacons	Transit	LORAN-C
	9 ± .8	5 ± .6	9 ± .4
		(Omega: 4 ± .4)	

RNS Accuracy Desired:		
	Open Ocean	2 nm ± .4 nm
	Coastal Waters	563 m ± 83 m
	Inland Waters	245 m ± 95 m
	Great Lakes	515 m ± 429 m

* not stated due to small number of system users in sample returns
nm = nautical miles m = meters

[1]As percent of total boating time

Highest Receiver Purchase Price for Boat:

More Accurate Replacement Unit	$1,750	±	$133
GPS Unit	1,561	±	58
Differential GPS Unit	1,653	±	76
GEOSTAR Unit	1,380	±	78
STARFIX Unit	1,499	±	74
STARFIND Unit	1,462	±	79

The mean values for length and price paid for boats are skewed towards the right (higher levels) because of the inclusion of 225 tugboats and barges (4% of all boats) in the sample. The database of USCG documented boats did not have a field to indicate boats by type. Hence, the tugboats and barges were unavoidably included in the sample because they could not be distinguished from other boats in the sampling frame of documented vessels.

4.1.2 RECEIVER POPULATION PROJECTIONS

Given the universe of 480,287 boats for the survey, 250,244 boats (52%) are estimated to have one or more radionavigation receivers. The estimates are based on projections made from the sample returns whose methodology is discussed in Appendix A. The standard error of the estimate is ± 6,564 at the 95% level of confidence.

The receiver populations and the corresponding standard errors are estimated below, also at 95% level of confidence. Note that, since some of the 250,244 boats had more than one receiver, either of the same kind or of different kinds, boats and receivers have been distributed in different receiver tables as follows:

(1) a boat with only one receiver has been counted in the relevant receiver table as one boat and adding to the receiver count of that table one unit;

(2) a boat with multiple receivers of the same kind has been

counted in <u>only one</u> relevant table as one boat but adding to the receiver stock of that table the requisite multiples;

(3) a boat with <u>multiple</u> receivers of <u>different</u> kinds has been counted in more than one receiver table, contributing to <u>each</u> relevant receiver table a boat count of one and adding to the receiver stock one or more units.

The net result is that the projected total number of receivers exceeds the total boat estimate of 250,244 because of multiple receivers in some boats. Also, the sum of boat totals in all receiver tables exceeds the projected total of 250,244 boats because of double-counting of boats equipped with multiple receivers of different kinds in some of the receiver tables.

A. <u>Radio Direction Finders</u>: There are an estimated 91,706 boats equipped with the RDF receivers, with a standard error of ± 5,014 boats. Installed in these boats are an estimated 98,891 RDF receivers, with a standard error of ± 5,407 receivers. Table 4-1 shows the distribution of boats and receivers by the number of receiver units installed in a boat.

TABLE 4-1

DISTRIBUTION OF RDF RECEIVERS

Units	Boats	Number of Receivers
1	85,183	85,183
2	6,145	12,290
3	94	282
4	284	1,136
TOTAL	91,706	98,891

B. <u>Omega Receivers</u>: The number of boats equipped with Omega receivers in the sample was very small, hence population projections for Omega boats and receivers have very large standard errors relative to the population size. The population of boats equipped with Omega receivers is estimated to be 1,220, with a standard error of ± 569 boats. Similarly, the Omega receiver

population is estimated to be 1,314 units, with a standard error of ± 613 receivers. The distribution of boats and Omega receivers by the number of units installed in each boat is shown in Table 4-2.

TABLE 4-2

DISTRIBUTION OF OMEGA RECEIVERS

Units		Boats	Number of Receivers
1		1,126	1,126
2		94	188
	TOTAL	1,220	1,314

C. Transit Receivers: Based on the sample data, a total of 15,475 boats are projected to be equipped with Transit receivers. The standard error for this projection is ± 2,186 boats. There are an estimated 15,852 receivers on these boats, with a standard error ± 2,240 receivers. The distribution of boats and receivers by the number of units in a boat is shown in Table 4-3.

TABLE 4-3

DISTRIBUTION OF TRANSIT RECEIVERS

Units		Boats	Number of Receivers
1		15,098	15,098
2		377	754
	TOTAL	15,475	15,852

D. LORAN-C Receivers: The population of LORAN-C equipped boats is estimated to be 211,110, with a standard error of ± 6,479 boats. The total number of LORAN-C receivers installed on those boats are estimated to be 234,662 units, with a standard error of 7,202 receivers. Table 4-4 shows the distribution of boats and LORAN-C receivers by the number of units installed in a boat.

TABLE 4-4

DISTRIBUTION OF LORAN-C RECEIVERS

Units		Boats	Number of Receivers
1		189,734	189,734
2		19,484	38,968
3		1,608	4,824
4		284	1,136
	TOTAL	211,110	234,662

Only a very small number of boats among the sample returns were equipped with the LORAN-A, Global Positioning System, and OMNI receivers. Using such small sample bases to make population projections and compute standard errors will yield unreliable results, hence such projections have not been included in this report.

4.2 CURRENT RADIONAVIGATION SYSTEMS: SYSTEM USAGE, COVERAGE, BENEFITS, AND PHASE-OUT PERIOD

The 1986 (and 1988) Federal Radionavigation Plan states that a major goal of the DOT and DOD is to recommend a mix of common-use RNSs which meets diverse user requirements, provides adequate capability for future growth, and minimizes duplication of services. The FRP also states that the Global Positioning System has the potential to replace many existing systems. In the light of these official pronouncements, the USCG felt that it needed comprehensive system use and user information on current radionavigation systems to prepare its recommendations to the Secretary of DOT on how to meet the FRP goal. Accordingly, the survey posed a series of questions on current systems, seeking respondent feedback on: systems used and usage rate, system coverage and accuracy, benefits and problems, and user preferences for the phase-out period of current systems following the introduction of GPS. The salient findings are reported below.

4.2.1 SYSTEMS AND USAGE

In the questionnaire, the respondents were asked to specify the number of receivers installed on their boats and, if more than one type of receivers were installed, to indicate which radionavigation system was used primarily. They were also asked to give information on how much they used each system in different waters.

4.2.1.1. Systems Used: As shown in Table 4-5, 48% of boats do not use any radionavigation system as they do not have any receiver on board. For 52% of boats equipped with one or more RNS receivers, the incidence of RNS usage is as follows: 30% of the boaters use LORAN-C only, 7% use Radiobeacons only, 1% use Transit only, 11% use LORAN-C and Radiobeacons, and 3% use a varied combination of all the systems mentioned plus Omega. The primary system used by the 14% of multi-system users (latter two categories) is: 12% use LORAN-C, and 1% each use Transit and Radiobeacons.

TABLE 4-5

CURRENT RADIONAVIGATION SYSTEMS USED BY BOATERS

SYSTEM USED	PERCENT	CUMULATIVE PERCENT
None	48	48
Radiobeacons only	7	55
Transit only	1	56
LORAN-C only	30	86
LORAN-C and Radiobeacons	11	97
Other Combinations*	3	100
		(5078)

*includes any combination of Radiobeacons, Transit, LORAN-C, OMEGA, LORAN-A, OMNI, and GPS.

4.2.1.2. Incidence of RNS Utilization: The survey results show a large variation in the incidence of RNS utilization in different waters among boaters. Grouping the data for boaters who use RNSs in different waters for 50% or more of boating time yielded an underlying pattern in RNS utilization. The results are reported in Table 4-6. Note that each cell value in Table 4-6 shows a segment of boaters only, namely, the percentage of RNS users among all boaters equipped with the receiver type for that cell only. Each cell value is, therefore, unrelated to any other column or row cell value. This is so because of the overlap of boaters among different cells. In the case of Radiobeacons system, the incidence of utilization is consistently low in all waters: 23% of boaters in the open oceans, 27% in coastal waters, 18% in inland waters, 9% in lakes and rivers, and 21% in Great Lakes. In contrast, the Transit system has a high incidence of usage in open oceans and coastal waters, but low incidence in other waters: 89% boaters in the open oceans, 54% in coastal waters, but only 17% in inland waters and 12% in Great Lakes. On the other hand, the LORAN-C system has the highest incidence of utilization in all waters except one: 73% of boaters in the open oceans, 77% in coastal waters, 47% in inland waters and 57% in Great Lakes, but only 11% in lakes and rivers. For the Omega system, the survey results are not reported here because, due to a small number of system users, a meaningful analysis is not possible.

4.2.2 COVERAGE AND ACCURACY

As a provider of electronic navigational aids to the marine user community, the USCG is keenly aware that the transmitted signal is limited in range and coverage and boaters tend to have diverse accuracy requirements. The survey, therefore, asked the respondents to rate the adequacy of the coverage of transmitted signals. It also queried respondents on their requirements for position accuracy and solicited their rating of the accuracy of different radionavigation systems.

TABLE 4-6

INCIDENCE OF RNS USAGE BY BOATERS IN DIFFERENT WATERS

SYSTEM	USE RATE	OPEN OCEANS	COASTAL WATERS	INLAND WATERS	LAKES/ RIVERS	GREAT LAKES
Radiobeacons	50%+	23%	27%	18%	9%	21%
		(264)	(523)	(210)	(58)	(133)
Omega	*	*	*	*	*	*
Transit	50%+	89%	54%	17%	0%	12%
		(123)	(94)	(34)	(12)	(15)
LORAN-C	50%+	73%	77%	47%	11%	57%
		(958)	(1519)	(784)	(178)	(428)

* not reported due to small number of users in sample returns

NOTE: Each cell value is unrelated to any other column or row cell because of overlap of boaters.

4.2.2.1 RNS Coverage: The signal coverage was generally acknowledged to be adequate by a very high percentage of boaters except, in the case of the Radiobeacons system, the percentage was smaller. As Figure 4-1 indicates, as many as 93% of boats with LORAN-C capability, 89% with Transit capability, and 84% with Omega capability had adequate RNS signal coverage. In contrast, only 71% of boats with Radiobeacons capability reported they had adequate signal coverage.

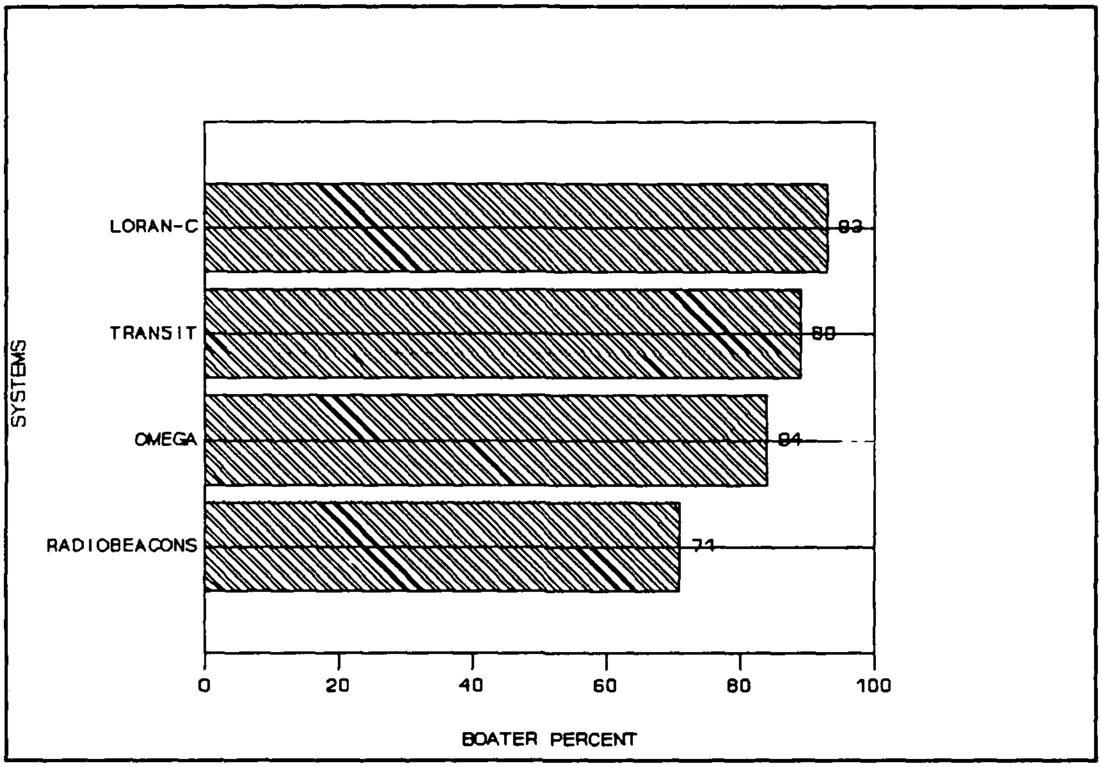

FIGURE 4-1. Systems Ratings for Adequacy of Signal Coverage

4.2.2.2 <u>Accuracy Requirements</u>: The level of accuracy desired by boaters is indeed determined by the expanse of water. Table 4-7 shows the boater accuracy requirements in different waters. In open ocean, for instance, the modal accuracy level preferred by 43% boaters is 0.25 nautical mile or less. The median accuracy level is 0.40 nautical mile or 741 meters. In coastal waters, the modal accuracy category is 91-100 meters for 17% of boaters, and the median is approximately 99 meters. In other waters, the modal accuracy category, percentage of boaters in the category, and the corresponding median accuracy level are, respectively, as follows: in inland waters 91-100 meters, 16%, and 63 meters; in lakes and rivers 10 meters or less, 25%, and 48 meters; and in the Great Lakes 91-100 meters, 18%, and 96 meters.

TABLE 4-7

BOATER ACCURACY REQUIREMENTS IN DIFFERENT WATERS

ACCURACY CATEGORY	PERCENT	CUMULATIVE PERCENT
	Open Ocean	
0.01 - 0.25 nm	43	43
0.26 - 0.50	12	55
0.51 - 0.75	1	56
0.76 - 1.00	18	74
1.01 and above	26	100
		(754)

ACCURACY CATEGORY	COASTAL WATERS	INLAND WATERS	LAKES & RIVERS	GREAT LAKES
010 m & Less	5	10	25	6
011 - 020 m	8	12	8	10
021 - 030	5	11	10	7
031 - 040	1	2	3	1
041 - 050	11	14	5	12
051 - 060	1	0	0	0
061 - 070	1	3	3	1
071 - 080	1	1	0	0
081 - 090	1	1	0	2
091 - 100	17	16	23	18
101 m & Above	49	30	23	43
	100	100	100	100
	(1194)	(541)	(34)	(236)

4.2.2.3 Satisfaction Rating of RNS Accuracy: Boaters are extremely satisfied with the LORAN-C system accuracy, less so with the Transit and Omega accuracies, and least with Radiobeacons system accuracy. As shown in Figure 4-2, over three-fourth (82%) LORAN-C users are very satisfied with its accuracy, versus two-third (66%) Transit and fewer than two-thirds (60%) Omega users,

and less than one-third (31%) Radiobeacons users. Among somewhat satisfied users are: less than one-fifth (17%) LORAN-C, about one-third each of Transit (30%) and Omega (33%) and more than half of Radiobeacons (58%) users. The most telling statistics, however, are the following: only 1% LORAN-C users are not at all satisfied with its accuracy, as against 4% Transit, 7% Omega and 11% Radiobeacons system users.

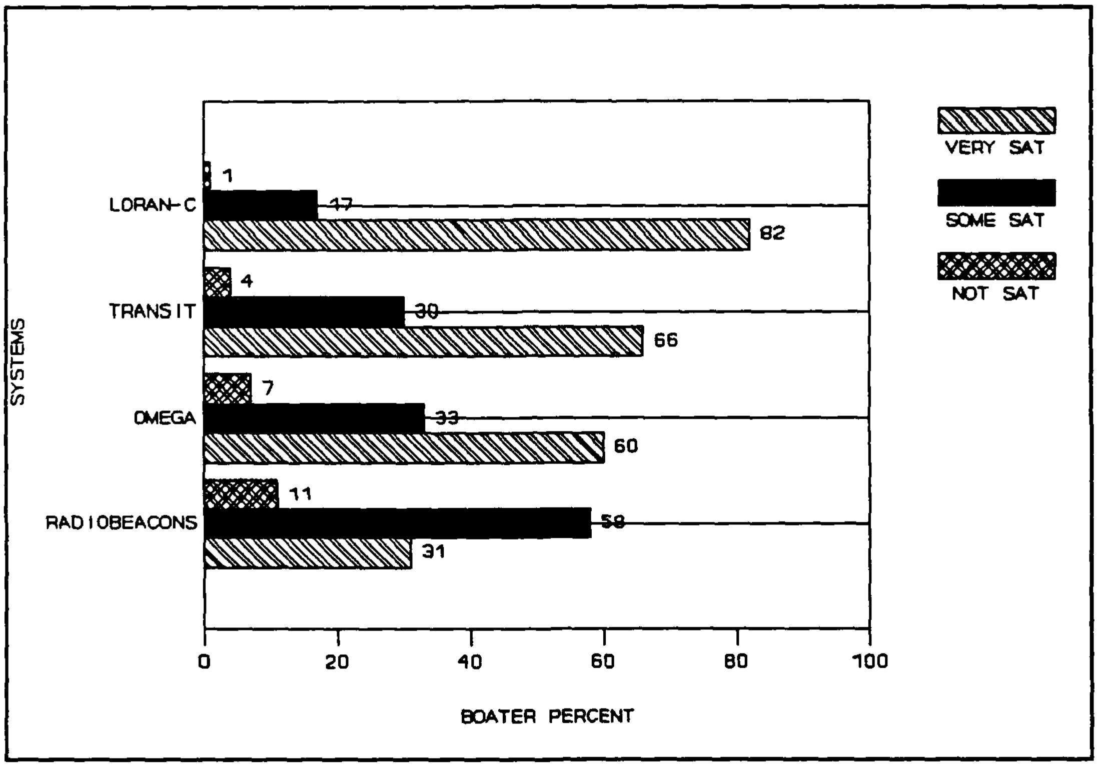

FIGURE 4-2. Satisfaction Rating of RNS Accuracy

4.2.3 <u>BENEFITS AND PROBLEMS</u>

The USCG provides electronic aids to navigation for the public's benefit. It is interested in knowing how boaters perceive the benefits and the value they put on those benefits. In addition, the USCG needs user feedback on the problems encountered while using the radionavigation systems. The survey posed these questions to the respondents.

4.2.3.1 RNS Benefits Rating: Boaters, in general, perceive RNSs as contributing to safety and time savings, but not nearly as much to fuel and indirect cost savings. Nearly all boaters (99%) rated RNSs as very important or somewhat important to improving navigational safety; only 1% denied its importance (see Figure 4-3). Similarly, 90% rated RNS favorably for time savings; 10% unfavorably. However, only three-fourths (76%) rated RNS as being very or somewhat important for fuel savings, and just over two-thirds (69%) for indirect cost savings.

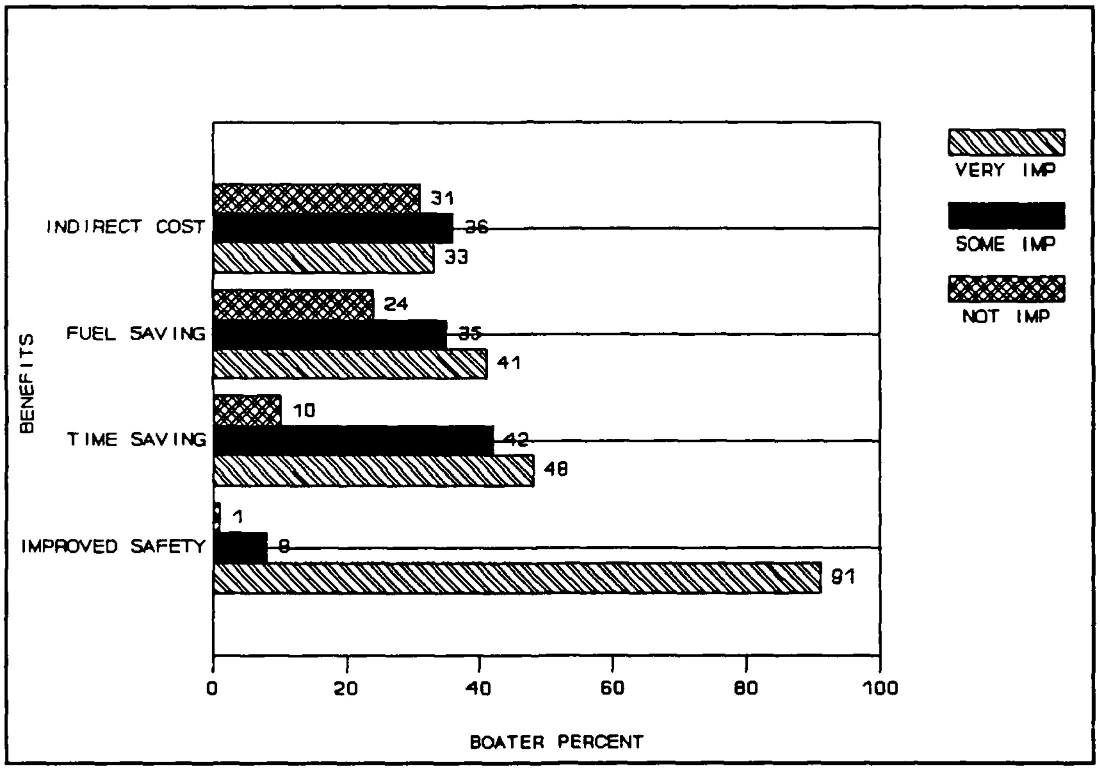

FIGURE 4-3. Rating the Importance of RNS Benefits

4.2.3.2 Savings Attributed to RNS: For most boaters, the amount of actual savings from using the RNSs are negligible. As shown in Table 4-8, no fuel savings are reported by over three-fourths (76%) of boaters using Radiobeacons, nearly two-thirds (64%) using Omega, 62% using Transit and by relatively smaller

percentage of over one-third (34%) of boaters using LORAN-C. Similarly, no time savings are reported by 63% of boaters using Radiobeacons, 60% using Omega, 44% using Transit and less than one-quarter (24%) using LORAN-C. The fact that relatively fewer LORAN-C users report no savings has an important implication: more boaters using LORAN-C apparently save fuel and time than boaters who use other systems. However, even for LORAN-C users the actual annual savings are only marginal. With only 8% (and 1%) reporting annual savings of 501 or more gallons (and hours), evidently as many as 92% (and 99%) of LORAN-C users report either no savings or up to 500 gallons (and hours) of annual savings.

TABLE 4-8

ANNUAL SAVINGS ATTRIBUTED TO RADIONAVIGATION SYSTEMS

	RADIOBEACONS	OMEGA	TRANSIT	LORAN-C
Fuel Savings (gallons)				
0	76%	64%	62%	34%
1 - 100	20	8	23	35
101 - 500	3	0	5	23
501 and above	1	28	10	8
	100	100	100	100
	(456)	(11)	(83)	(1460)
Time Savings (hours)				
0	63	60	44	24
1 - 100	36	18	44	69
101 - 500	1	11	11	6
501 and above	0	11	1	1
	100	100	100	100
	(419)	(11)	(77)	(1415)

4.2.3.3 RNS Problems: Whether a boater encounters problems of signal loss, weakness or interference depends on many factors: chiefly on whether the distance traveled is beyond or on the fringe of signal coverage area; the type and quality of receiver installed; and the extent to which the boater deviates from the routine travel pattern into unknown waters where signal quality may be poor. Apparently, such factors are not a unique property of any one RNS, rather they are intrinsic to all RNSs as evidenced by the pervasiveness of RNS problems across different RNSs (see Table 4-9). However, the incidence of RNS problems varies from one system to another. A review of the incidence data for each system shows there are two classes of boaters: (1) those experiencing no signal problems and (2) those who do. In the former class, more of LORAN-C (31-43%) and Transit users (35-57%) report no signal problems than Radiobeacons users (17-35%). In the latter class, two tendencies are found: (1) among boaters experiencing signal problems up to 20% of total boating time, more LORAN-C users (53-60%) report signal problems than Radiobeacons users (41-48%) and Transit users (33-50%); and (2) among boaters experiencing signal problems more than 20% of boating time, more Radiobeacons users (24-39%) report signal problems than LORAN-C users (4-9%) and Transit users (10-29%). The reasons for inconsistencies in the reported signal problems for the LORAN-C system, from better to worse to better performance than Radiobeacons system, are not altogether clear at this time and require further analysis. Once again, the Omega system signal problems are excluded from the preceding discussion because, due to the low usage rate of the system, the sample base was small to permit a meaningful analysis.

TABLE 4-9

INCIDENCE OF RNS PROBLEMS ENCOUNTERED

BOATING TIME	RADIOBEACONS	TRANSIT	LORAN-C
	Signal Loss		
0%	35%	35%	43%
1 - 20%	41	36	53
21 - 100%	24	29	4
	100	100	100
	(360)	(80)	(1226)
	Signal Weakness		
0%	17%	40%	31%
1 - 20%	44	50	60
21 - 100%	39	10	9
	100	100	100
	(393)	(60)	(1273)
	Interference		
0%	28%	57%	36%
1 - 20%	48	33	58
21 - 100%	24	10	6
	100	100	100
	(247)	(39)	(1048)

4.2.4 PHASE-OUT PERIOD

With the prospect that GPS might replace many current radionavigation systems in the mid 1990s, the USCG desired user feedback on how long the current systems ought to be continued after GPS became fully operational. Accordingly, the survey respondents were asked to state their preferences for the period when each current system might be phased out in favor of the GPS.

4.2.4.1 Transition Periods From Current RNSs to GPS: Given a choice, boaters prefer gradual phasing out of current systems

(see Table 4-10). The following statistics give, for each current RNS, the modal category for the transition period to GPS, the percentage of boaters for that category, and the median period of transition: for Radiobeacons 1-5 years, 51%, 3.5 years; for Omega 1-5 years, 49%, 1.5 years; for Transit 1-5 years, 53%, 2.5 years; for LORAN-C 1-5 years, 55%, 4.3 years. Note that the transition period for all RNSs was capped at 50 years maximum.

TABLE 4-10

PHASE-OUT PERIOD FOR CURRENT RADIONAVIGATION SYSTEMS

YEARS	RADIOBEACONS	OMEGA	TRANSIT	LORAN-C
0	14%	35%	24%	3%
1 - 5	51	49	53	55
6 - 10	20	13	17	29
11 and above	15	3	6	13
	100	100	100	100
	(1213)	(412)	(563)	(3064)

4.3 PROPOSED RADIONAVIGATION SYSTEMS: AN ASSESSMENT OF BOATER PREDISPOSITION TOWARDS MORE ACCURATE SYSTEMS

The USCG anticipates that the satellite-based systems will be in place by early 1990s. With this prospect, the USCG is faced with the question: what is a boater's general predisposition towards more accurate systems and, particularly, the satellite-based systems? In line with this general question, the survey asked respondents to specify their predisposition towards the more accurate systems, including the somewhat better known satellite-based systems. The salient findings are reported below.

4.3.1 DIFFERENTIAL LORAN-C

With respect to the differential LORAN-C service, the survey solicited boater reaction to the potential availability of the more accurate service at no cost to the public. The respondents were

asked to specify if they would purchase a new receiver, modify an existing receiver, or rather not use the service.

4.3.1.1 <u>Reaction to Free Differential LORAN-C Service</u>: Boaters' reaction to the differential LORAN-C service even when freely provided by the government was not overwhelmingly enthusiastic. As Figure 4-4 shows, over a quarter (26%) of boaters plainly stated they would be unlikely users of the service, and nearly half (47%) opted to modify the current LORAN-C receiver for the differential service which is more an expression of intent than an outright commitment to using the service. Only over a quarter (27%) of boaters committed to purchasing a differential receiver.

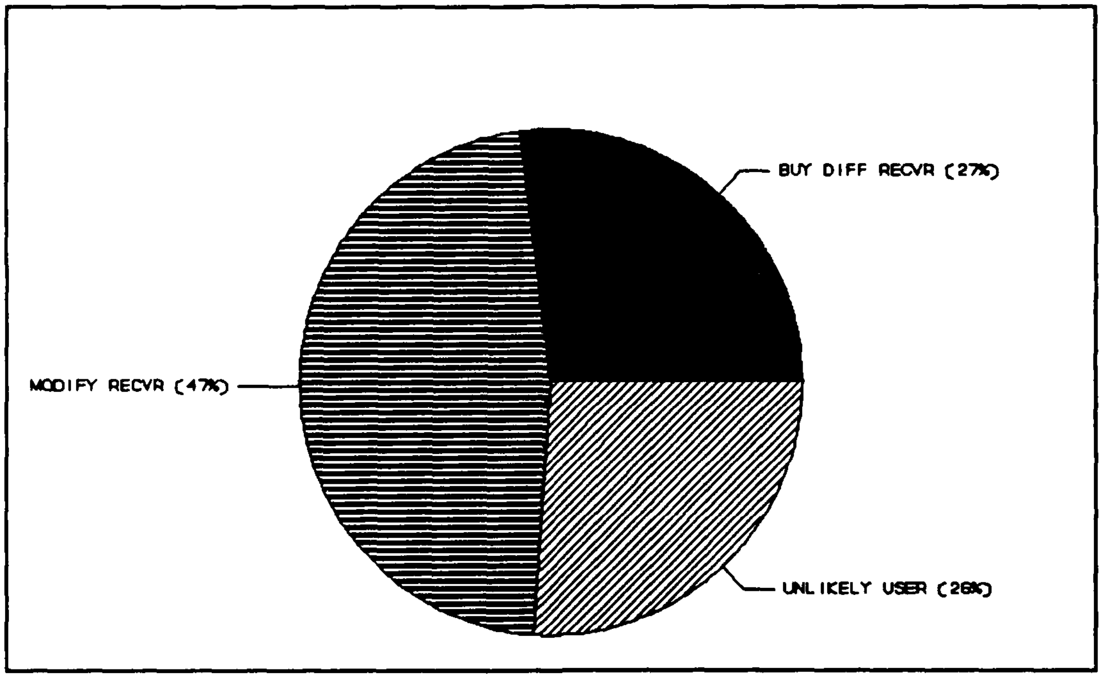

Figure 4-4. Reaction to Differential LORAN-C Free Service

4.3.2 <u>GLOBAL POSITIONING SYSTEM</u>

The GPS has been under development for over a decade. It has been talked about in the radionavigation user community and written about in various publications such as newspapers and magazines for

even longer. The USCG is, therefore, interested in the awareness level among boaters and their rating of the perceived accuracy benefits.

4.3.2.1 Familiarity with GPS: A majority of boaters pleaded ignorance of the GPS. This is quite alarming given that GPS is scheduled to be fully operational by the mid 1990s. As Figure 4-5 shows, almost two-thirds (63%) of boaters said they had no knowledge or experience with the GPS. Only 3% of boaters indicated that they had some operational experience with the GPS, and over one-third (34%) stated they had no experience but were informed by reading literature on the subject.

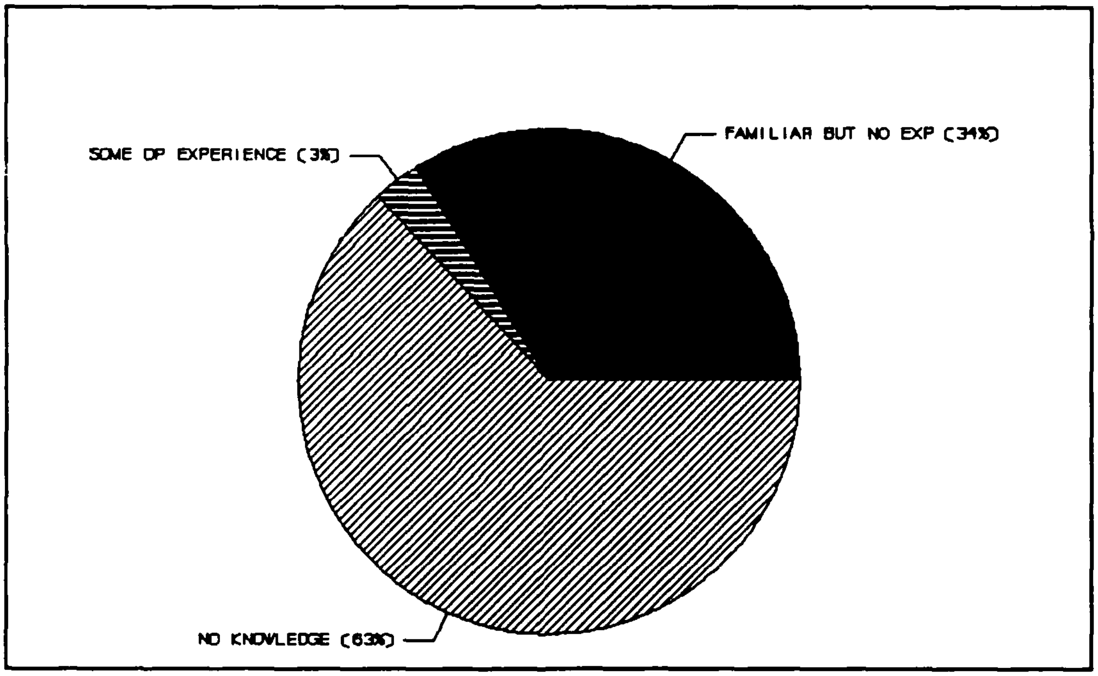

FIGURE 4-5. Familiarity with GPS

4.3.2.2 Benefit from Increased GPS Accuracy: As Table 4-11 shows, although over half the boaters acknowledged they would benefit from increased positional accuracy of 100 meters provided by the GPS, a substantial percentage disavowed any such benefit:

57% boaters affirming the benefit, as against 43% denying it.

TABLE 4-11

GPS ACCURACY* VIEWED AS POTENTIAL BENEFIT

RESPONSE	PERCENT	CUMULATIVE PERCENT
Will benefit from GPS accuracy	57	57
Will not benefit	43	100
		(4650)

*100 meters or better horizontally

4.3.3 DIFFERENTIAL GLOBAL POSITIONING SYSTEM

As in the case of differential LORAN-C service, the survey asked the boaters for their reaction to the likely prospect of differential GPS being available at no cost to the public.

4.3.3.1 Reaction to Differential GPS: The reaction to the availability of differential GPS was divided between those expressing no interest and boaters showing a commitment to using it by purchasing differential GPS receivers, on the one hand, and a small number professing the intent to use the service, on the other. The commitment shown by a large number of boaters is surprising in view of the widespread ignorance of GPS among boaters. Thus, whereas half (50%) of boaters expressed no interest, 41% indicated they would purchase differential receivers (see Figure 4-6). The remaining 9% opted to modify an installed GPS receiver for the differential service.

4.3.4 PRECISE POSITIONING SERVICE

The GPS Precise Positioning Service provides the highest level of accuracy and the Government intends to provide this capability to qualified users of the civil community. The USCG is, therefore, interested in knowing what percentage of boaters will need the service.

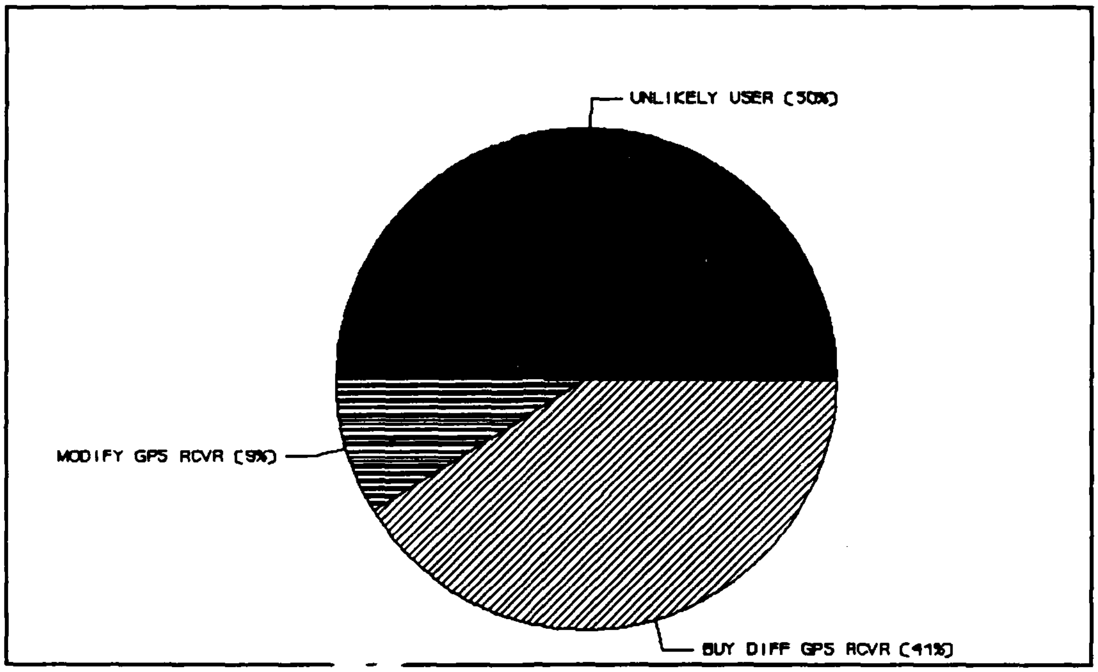

FIGURE 4-6. Reaction to Differential GPS Free Service

4.3.4.1 <u>Access to PPS</u>: A majority of boaters responded negatively to the question of whether they would require access to Precise Positioning Service (PPS), and a sizable number were noncommittal (see Table 4-12). Whereas two-thirds of boaters flatly stated they would not require access to PPS, and over a quarter (28%) said they were not sure if they would use the service, only a small number (6%) of boaters indicated they intended to use the PPS.

TABLE 4-12

<u>BOATERS REQUIRING ACCESS TO PPS</u>

RESPONSE	PERCENT	CUMULATIVE PERCENT
PPS access not required	66	66
Not sure	28	94
PPS access required	6	100
		(4680)

4.3.5 PRIVATE SATELLITE-BASED SYSTEMS

Apart from the public GPS, there are also a number of radionavigation systems developed privately that operate with varying accuracy. The survey asked respondents to indicate their level of familiarity with and also their need for the planned accuracy of these systems.

4.3.5.1 Familiarity with Private Satellite-based Systems: More boaters are ignorant of private satellite-based RNSs than GPS. Table 4-13 indicates that a preponderant number of boaters, ranging from 93% for GEOSTAR and 96% for STARFIX to 97% for STARFIND, are not familiar with the private satellite-based RNSs.

TABLE 4-13

FAMILIARITY WITH PRIVATE SATELLITE-BASED SYSTEMS

FAMILIARITY LEVEL	GEOSTAR	STARFIX	STARFIND
Not Familiar	93%	96%	97%
Somewhat Familiar	6	4	3
Very Familiar	1	0	0
	100	100	100
	(4592)	(4545)	(4534)

4.3.5.2 Need for Planned Accuracy of Private Satellite-based Systems: When boaters in the sample were queried on the need for accuracy levels planned for private satellite-based RNSs, there were as many non-respondents as respondents. Such responsiveness suggests that half of the boaters simply are not interested in the accuracy of either the high 6 meters or the low 100 meters. Among the respondents, as shown in Table 4-14, more than half acknowledged that the planned accuracy of each system would satisfy their requirements: 51% opting for the GEOSTAR system planned accuracy of 100 meters, 61% for the STARFIX planned accuracy of 10 meters, and 58% for the STARFIND planned accuracy of 6 meters.

TABLE 4-14

BOATERS SIGNIFYING NEED FOR ACCURACY OF PRIVATE SATELLITE-BASED SYSTEMS

NEED FOR ACCURACY	GEOSTAR (100 m)	STARFIX (10 m)	STARFIND (6 m)
Yes	51%	61%	58%
No	49	39	42
	100	100	100
	(2666)	(2651)	(2496)

4.4 RECEIVING SYSTEMS: UNIT(S) INSTALLED AND REPLACEMENT PRICING AND PLANS

Boaters using electronic aids in navigation employ one or more receivers on board to get position, direction, range, time and so on. Some of these receivers are strictly one system receivers while others, the hybrid receivers, have the capability of receiving information from two or more independent systems. The USCG is interested in information on receiving systems because these systems provide important clues to how boaters use receivers for navigation purposes. Accordingly, the survey addressed several questions on the receiving systems to the respondents: how many receivers are installed, how boaters rate their receiver accuracy, what are the typical receiver applications for information in navigation, what purchase plans boaters have for the next two years and what are boater preferences for the replacement cost of receivers? The salient findings are reported below.

4.4.1 UNITS INSTALLED

In the survey, respondents were asked to indicate the number of receivers installed in their boats.

4.4.1.1 Number of Receivers Installed: On about 48% of boats, as Table 4-15 shows, no receivers have been installed, hence these boats do not use any RNS. Among 52% of boats equipped with receivers, 38% have one receiver only and 14% have two or more.

TABLE 4-15

DISTRIBUTION OF RECEIVERS INSTALLED ON BOATS

RECEIVERS ABOARD	PERCENT	CUMULATIVE PERCENT
0	48	48
1	38	86
2 and above	14	100
		(5078)

4.4.2 RECEIVER APPLICATIONS

Generally, the receiver applications depend on the boater navigation information requirements. For instance, boaters who do not venture too far to be out of sight of the shore line may have the simple requirement of finding direction only. On the other hand, boaters who are avid sports fishermen may have multiple requirements of not only finding direction but also position in order to reach the spot where fishing has been traditionally good. Accordingly, the information on receiver applications was solicited in two parts: how the receivers are used and what is the primary usage, if receivers have multiple applications.

4.4.2.1 Receiver Information Applications: Most boaters use RNSs to obtain position only or position in combination with other applications such time, speed, etc. (see Table 4-16). The use of Radio Direction Finders (RDF) for bearing information by boaters is as follows: 31% of boaters with RDFs get direction (or homing) information only, 32% obtain position fixes only, 36% obtain both position and direction, and 1% obtain information on position or direction in combination with waypoints or location of other boats.

TABLE 4-16

RECEIVER APPLICATIONS

INFORMATION	RADIOBEACONS	TRANSIT	LORAN-C
Direction only	31%	na	na
Position only	32	62%	90%
PTTI only	na	1	0
Various combinations	37	37	10
	100	100	100
	(1001)	(151)	(2107)

na = not applicable

The primary use of the RDFs among the latter 37% boaters who obtain information of more than one kind is: 18% boaters with RDFs primarily obtain direction or homing information and 19% obtain position fixes.

As for use of the Transit receivers, 62% of boaters with Transit receivers obtain position information only, 1% Precise Time and Time Interval (PTTI), 33% position in combination with PTTI information and 4% obtain position or PTTI in combination with waypoints. The primary use of the Transit receivers among the latter 37% boaters who derive more than one type of information is: 35% use the receivers primarily for obtaining position, 1% for PTTI, and 1% for a combination of position and PTTI.

In contrast to Radiobeacons and Transit receiver usage, 90% of boats with LORAN-C receivers obtain position only, 6% position and PTTI, 3% position and boat speed, and 1% obtain other combinations of information including fog navigation. The techniques employed for position determination are: 23% of boats with LORAN-C receivers utilize receivers to obtain a position fix (longitude/latitude) either in the normal mode from the receiver display or in the repeatable mode from stored waypoints, 10% in the normal mode to obtain position only from receiver display, 7% in the normal mode to read Time Differences (TDs) only and then plot

on chart to get position, 5% use receivers in the repeatable mode to steer to a waypoint stored in the receiver, 1% employ receivers in the repeatable mode to compare TDs from the receiver with previously measured values to return to a location, another 1% use receivers in the rho-rho mode to determine range only and the remaining 53% obtain a position fix by combining some or all the techniques mentioned. Among approximately 71% boats with the LORAN-C receivers who obtain position in more than one mode use the receivers primarily as follows: 33% use the receivers primarily in the repeatable mode to obtain position, 32% in the normal mode, 5% in a mix of both modes and 1% use the receivers in the normal mode to determine boat speed.

The Omega receiver applications are not discussed here because of the small number of system users in the sample returns.

4.4.3 RECEIVER PERFORMANCE

In asking the respondents to rate the performance of their receiver(s), the question put to them was whether the current receiver(s) met all their accuracy requirements.

4.4.3.1 Receiver Accuracy Rating: In most boaters' view, the receiver(s) installed on their boats is sufficiently accurate. Table 4-17 shows that over three fourths (76%) of boaters with radionavigation equipment on board believe that current receiver(s) meet all their accuracy requirements; about one-fourth (24%) contend otherwise.

TABLE 4-17

CURRENT RECEIVER(S) ACCURACY RATING

RESPONSE	PERCENT	CUMULATIVE PERCENT
Meets accuracy requirements	76	76
Does not meet requirements	24	100
		(2481)

4.4.4 NEW RECEIVER PURCHASE PLAN

The boater purchase plans for new receivers are a good indicator of which radionavigation systems they currently prefer. Respondents were, therefore, asked to indicate what new radionavigation receiver they planned to buy within the next two years.

4.4.4.1 Receiver Purchase Plan: As Figure 4-7 indicates, a majority of boaters (59%) surveyed do not plan to buy a receiver within the next two years. Of the 41% who declared their intent to purchase a receiver, most preferred LORAN-C over other RNSs. Specific percentages are: 29% indicated they would buy a LORAN-C receiver, 4% opted for a hybrid receiver, another 4% for a Radio Direction Finder, 3% said they would buy a Transit receiver and 1% a GPS receiver.

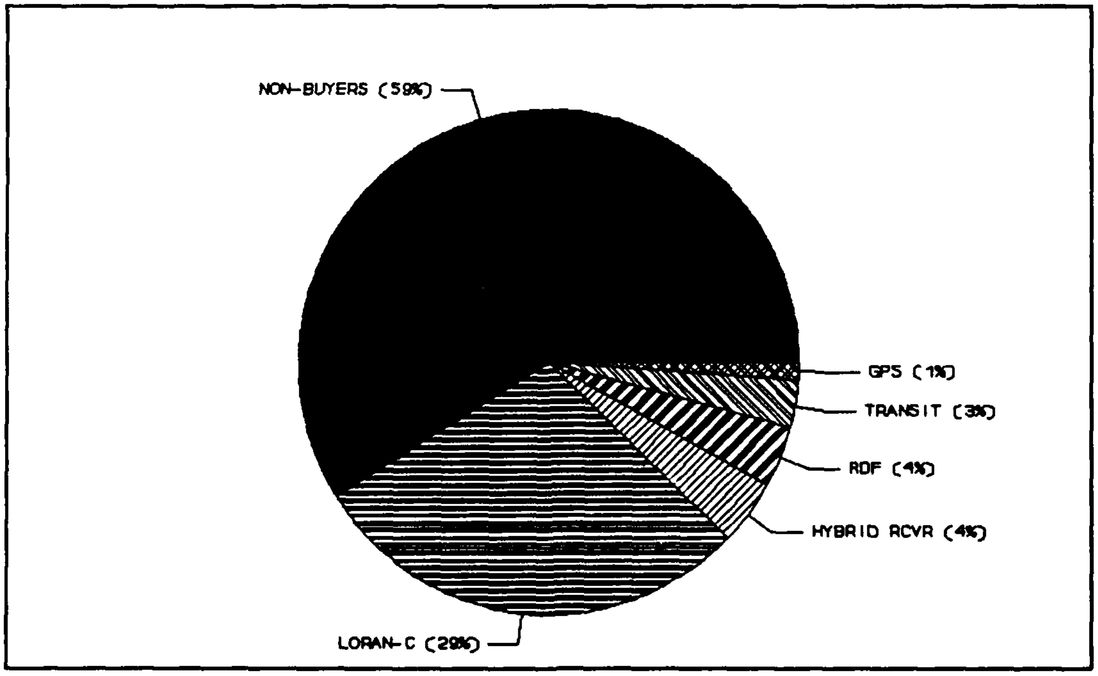

FIGURE 4-7. Receiver Purchase Plans in the Next Two Years

4.4.5 REPLACEMENT UNIT PRICING PREFERENCES

The price consumers are willing to pay for a product generally reflects the intensity of demand, given the current supply conditions. This is also true for a new product not yet introduced in the market, provided consumers have been made aware of it and have formed an opinion on how it will meet their needs. Accordingly, the USCG is interested in knowing what price boaters are inclined to pay for more accurate receivers for current or the proposed satellite-based radionavigation systems.

4.4.5.1 Prices For More Accurate Replacement Receivers: As Table 4-18 indicates, for each more accurate receiver in which the respondents indicated an interest, the modal price category, percentage of boaters for the category and the median price are, respectively, as follows: for a replacement unit (whose pricing data reflects the preferences of a segment of respondents who disclaimed their current receiver(s) met their navigation accuracy requirements) $501-1000, 38% and $1,067; for a GPS receiver $501-1000, 36% and $972; for a differential GPS receiver $501-1000, 33% and $1,033; for the GEOSTAR receiver $501-1000, 37% and $865; for the STARFIX receiver $501-1000, 34% and $985; and for STARFIND receiver $501-1000, 34% and $971. Overall, half the boaters are apparently willing to spend about $1,000 for a new receiver which will provide higher accuracy than one currently installed.

4.5 BOAT ATTRIBUTES: SELECTED CHARACTERISTICS

To obtain a statistical profile of boats and boating characteristics, the survey respondents were asked to give the following information: boat length, price paid, period of ownership, purpose(s) for which the boat is used, period of operation, area of operation, receivers installed and electronic fixtures on board. The salient findings are discussed below.

TABLE 4-18

HIGHEST PRICE FOR MORE ACCURATE REPLACEMENT RECEIVERS

RECEIVER TYPE	$500 & <	$501-1000	$1001-1500	$1501+	TOTAL
Replacement Unit	10%	38%	15%	37%	100% (553)
GPS	16	36	14	34	100 (2166)
Differential GPS	16	33	15	36	100 (1455)
GEOSTAR	23	37	11	29	100 (1062)
STARFIX	17	34	15	34	100 (1262)
STARFIND	18	34	15	33	100 (1098)

4.5.1 LENGTH OVERALL

The respondents were asked to specify the length of their boats in feet.

4.5.1.1 Boat Length: The survey results show that 40% of boats are 26 to 30 feet in length overall, and this is the modal length category (see Figure 4-8). The remainder of boats are in the following length categories: 22% of the boats are 31 to 35 feet in length, 16% are between 36 to 40 feet, 8% between 41 to 45 feet, and 14% are 46 feet and above in length. The median length is 32 feet, which suggests that half the boats vary from 26 to 32 feet in length.

4.5.2 WATERS IN WHICH BOATS ARE OPERATED

The respondents were asked to specify the waters in which they operated their boats, not counting occasional excursions or side

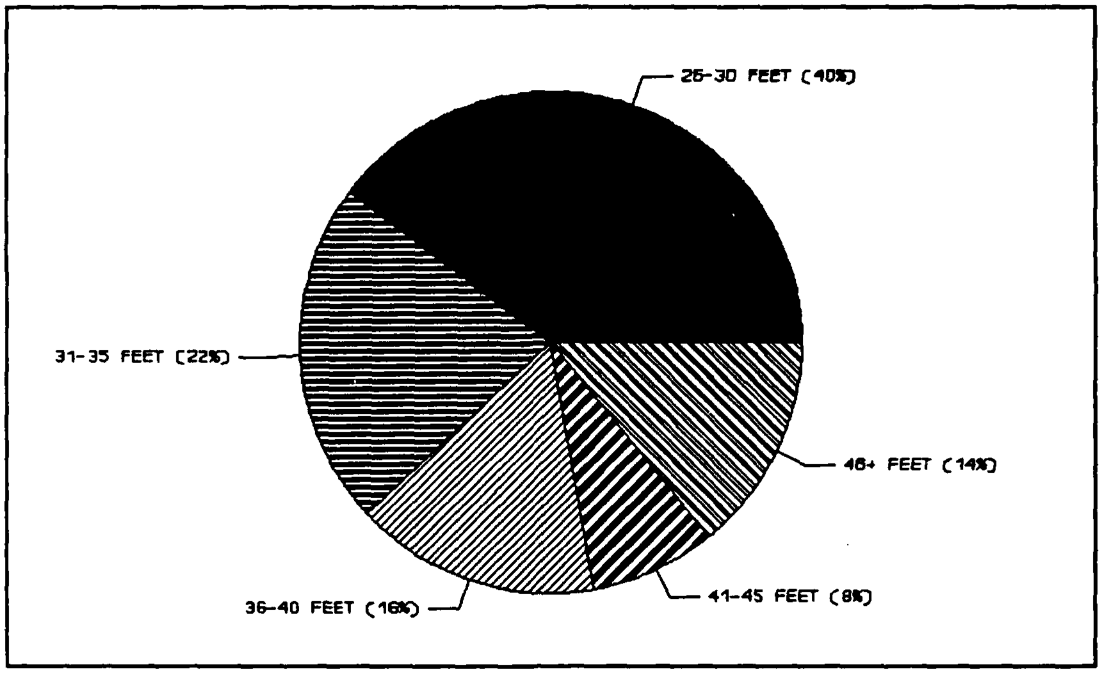

FIGURE 4-8. Boats by Length

trips. The water categories listed in the questionnaire were: open ocean, coastal waters, inland waters with access to coastal waters, lakes or rivers with no outlet to coastal waters and Great Lakes.

4.5.2.1 Type of Waters: Coastal waters (defined as less than 50 nm from shore) is the modal category for over 28% of boats, closely followed by inland waters for almost 27% and a combined category of the both inland and coastal waters for over 13%, giving a total of 68% of boats operating in coastal and inland waters only (see Figure 4-9). The frequency count for boats operating only in the Great Lakes is 11%, and in lakes and rivers is 7%. In contrast, only 2% of boats operate primarily in open oceans (defined as 50 and more nm from shore). The remaining 12% operate in a combination of waters, with 4% in open ocean/coastal/inland waters, 3% in open ocean/coastal waters, 1% in coastal/inland/Great Lakes waters and 4% in other combination of waters.

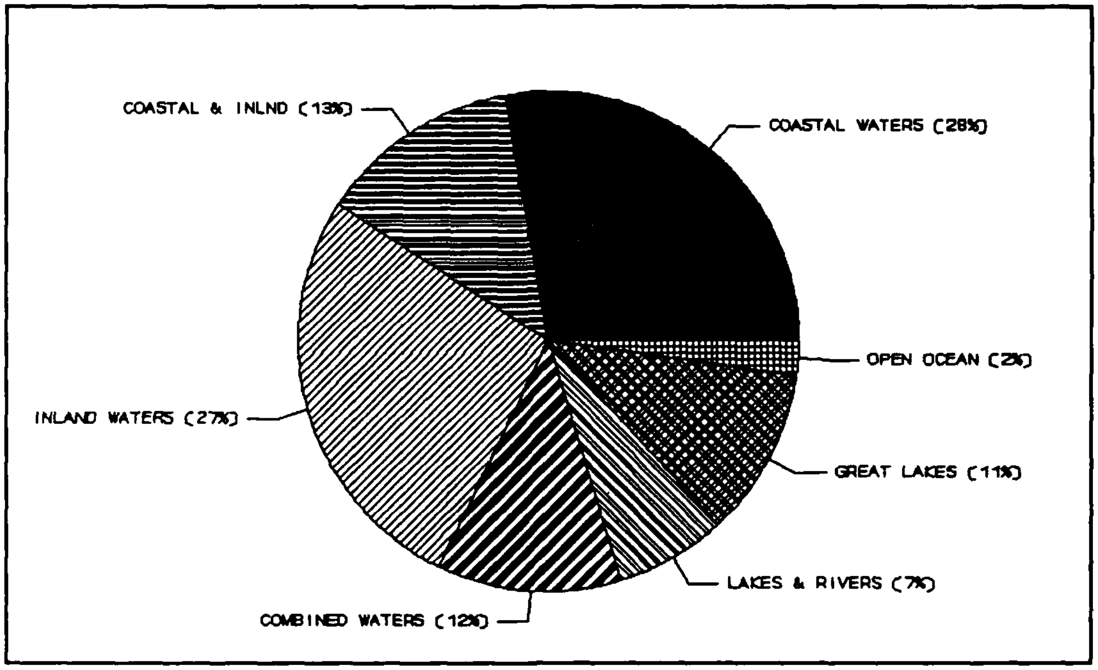

FIGURE 4-9. Waters Where Boats are Operated

4.5.3 <u>REGIONS IN WHICH BOATS ARE OPERATED</u>

The respondents were asked to specify the state waters in which they typically operated their boats. The states identified by the respondents were subsequently grouped into regions as defined in the Statistical Abstract of the United States.

4.5.3.1 <u>Regions</u>: As Table 4-19 shows, 22% of boats operate exclusively in the South Atlantic region from Maryland to Florida and over 19% in the Pacific region, including Hawaii. In the East North Central region only, consisting of the Great Lakes states, over 11% of boats are operated. Other regions where a substantial number of craft operate exclusively are: Mid Atlantic (New Jersey, New York, and Pennsylvania) with 8%, New England with 7%, a combined category of Mid Atlantic and New England with 5%, and West South Central region of Gulf States with 7%. The remaining 21% of

TABLE 4-19

REGIONS IN WHICH BOATS ARE OPERATED

REGIONS	PERCENT	CUMULATIVE PERCENT
South Atlantic	22	22
Pacific	19	41
East North Central	11	52
Mid Atlantic	8	60
New England	7	67
New England/Mid Atlantic	5	72
West South Central	7	79
Others	21	100
		(5051)

boats operate in other regions: East South Central, West North Central, Mountain, Great Lakes, US Territories, Canada, Mexico, Caribbean Islands, world-wide, and various combination of regions.

4.5.4 PERIOD OF OPERATION

For information on the period of operation, the respondents were asked to identify months in which they typically operated their boats.

4.5.4.1 Months Boats Are Operated: The modal period of operation is 12 months for 38% of the boats (see Figure 4-10). While many of these boats are engaged in activities of a commercial nature, a sizable percentage are used for recreational purpose year round, especially along the southern Atlantic and Pacific coasts. In contrast to year round boating, summer time boating spans 5 to 7 months, during which time 37% of boats are operated, especially along the upper (north and mid) Atlantic and Pacific coasts, and in the Great Lakes. During these months, boats are presumably used for all purposes, but primarily for recreation. The remaining 25% of boats are operated in two different time periods: 17% for a

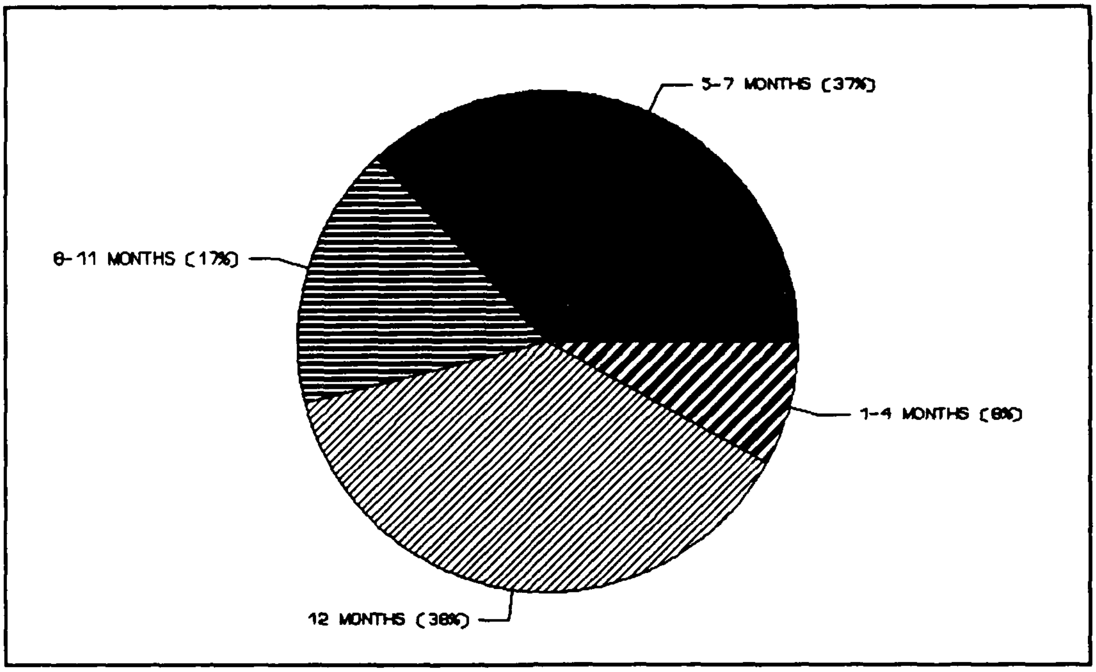

FIGURE 4-10. Periods in Which Boats are Operated

longer span of 8 to 11 months mostly for commercial purposes along the lower (southern and Gulf) Atlantic and Pacific coasts and 8% for a shorter span of 1 to 4 months for recreation by occasional boaters in all maritime states. The median period of operation for all boats is 8 months.

4.5.5 PURPOSE FOR WHICH BOATS ARE PRIMARILY OPERATED

The intent of the question on purpose was to determine whether boats are operated for recreation, commercial, or some other purpose.

4.5.5.1 Purpose: Three-fourths of boats are operated solely for recreation, as Figure 4-11 shows. In contrast, only 18% are used solely for various commercial purposes which include 9% of boats for commercial fishing, 5% for business and 4% for barging. The remainder 7% are used as follows: 6% in multi-purpose operations, and 1% for living aboard, research and racing.

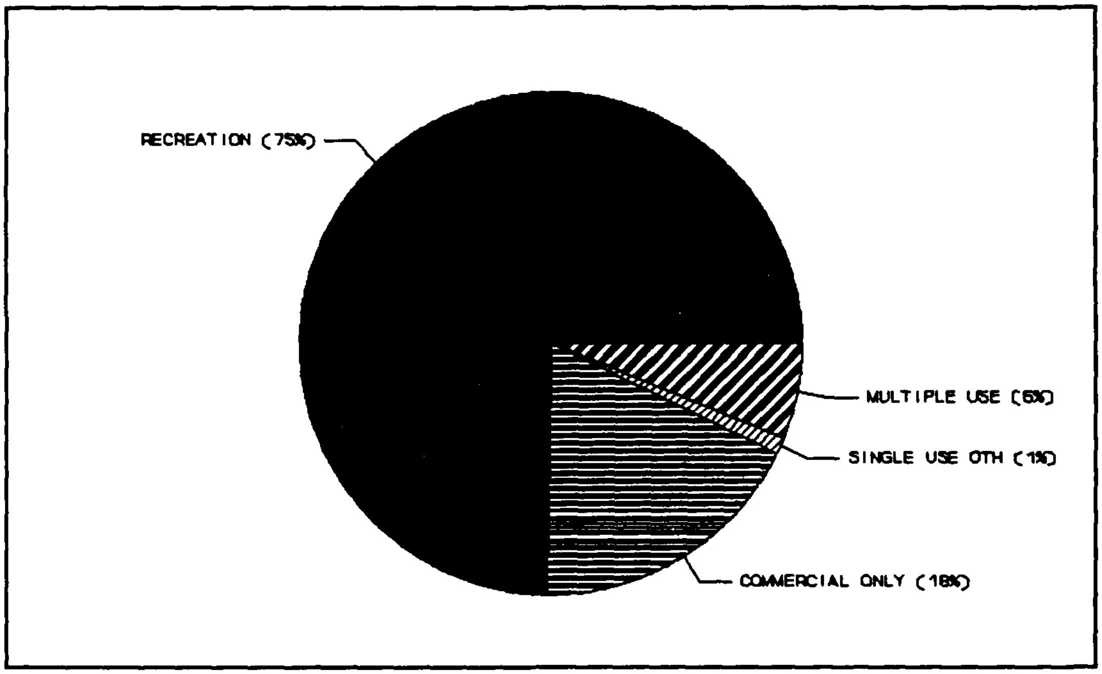

FIGURE 4-11. Purpose of Boating

4.5.6 PRICE PAID

The respondents were asked, to the best of their knowledge, what price did they pay to acquire the boat?

4.5.6.1 Boat Price: As Figure 4-12 shows, 15% of boaters have paid $10,000 or below for their boats, 16% between $10,001-20,000 (the modal category), 14% between $20,001-30,000 and 11% between $30,001-40,000. Cumulatively, these boaters (56%) acquired their boats for $40,000 or less. Of the remainder, 28% of boaters paid a price ranging from $40,001 to $100,000, and 16% lumped together in the graph paid over $100,000. The median price paid is $34,545.

If prices paid for boats 26 feet or more in length do not seem sufficiently high, the reason seems to be that a substantial number were apparently purchased as used boats. (See section 4.5.7.1 below). Moreover, the period of ownership for boats is quite long with 50% of boats acquired more than 5 years ago (see section

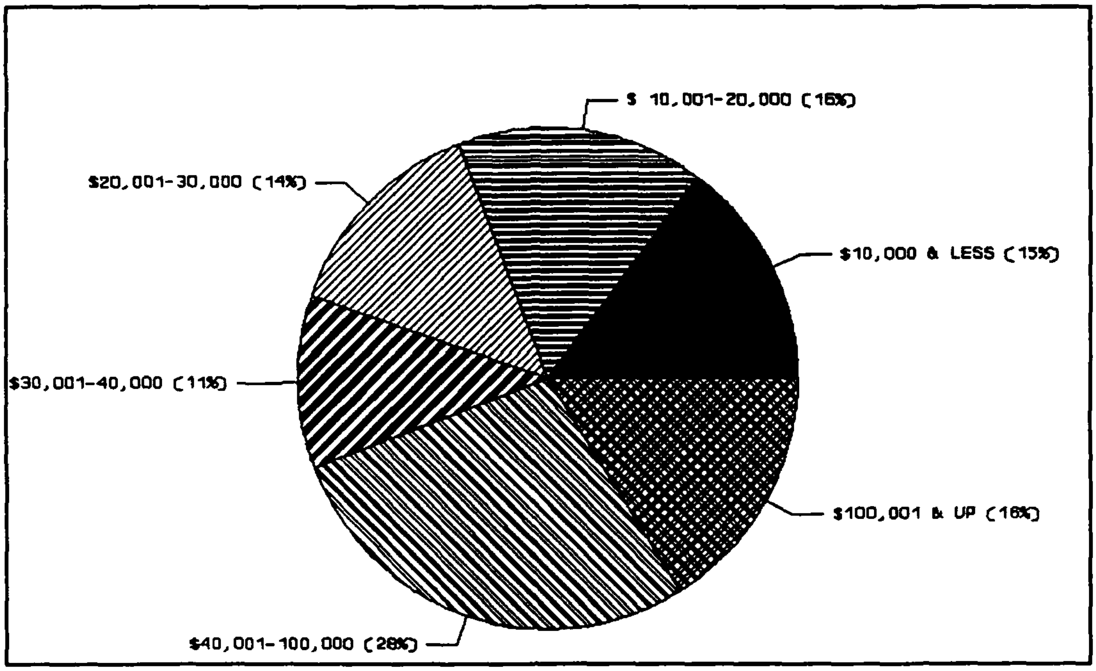

FIGURE 4-12. Price Paid for Boats

4.5.6.1). Consequently, averaging the prices paid in earlier years, when prices were generally lower, with those paid more recently when they are generally higher, tends to depress the overall statistic.

4.5.7 <u>LENGTH OF OWNERSHIP</u>

To determine the length of ownership, the respondents were asked to specify the year in which they had acquired their boats. Based on this information, the length of ownership was computed.

4.5.7.1 <u>Ownership</u>: The length of ownership of boats (see Table 4-20) varies considerably ranging from less than 1 year for 2% of boats to 41 years and above for 1%. The modal ownership is 2 years for 13% of boats, followed by ownership of 3 years for 11% of boats, 1 year for 9%, 4 years for another 9%, and 5 years for 6%. The median length of ownership is 5 years. As for the upper half of the median, the ownership varies from 6-10 years for 24% of boats, 11-20 years for 20%, 21-30 years for 4%, 31-40 years for

1%, and 41 years and above for another 1%.

TABLE 4-20

YEARS OF OWNERSHIP OF BOATS

YEARS OWNED	PERCENT	CUMULATIVE PERCENT
Less than 1 year	2	2
1 year	9	11
2 years	13	24
3	11	35
4	9	44
5	6	50
6	5	55
7	4	59
8	5	64
9	5	69
10	5	74
11 - 20	20	94
21 - 30	4	98
31 - 40	1	99
41 and above	1	100
		(4964)

4.5.8 PURCHASED AS NEW

Suspecting that a sizable number of boats, like automobiles, are purchased new, the respondents were asked, by way of confirmation, if their boats had been purchased new.

4.5.8.1 Newly Purchased: Over a third of the respondents (34%) reported that their boats had been purchased new (see Table 4-21). The remaining two-thirds either purchased used boats or did not answer. Assuming the former was more likely than the latter, the statistic indicates a sizable secondary market for boats.

TABLE 4-21

PERCENT OF BOATS PURCHASED NEW

New Boat Purchased	34
Used Boat Purchased and No Answer	66
TOTAL	100
	(5110)

4.5.9 STATUS INFORMATION SOURCES

The questionnaire listed a number of sources generally used by the boaters to get status information on navigation aids as well as an unspecified other category and asked them to specify all the sources they had used.

4.5.9.1 Use of Status Information Sources: More than a quarter of boaters have little need for status information and others rely primarily on radio. Specifically, as Table 4-22 indicates, 27% of the boaters do not get any status information and, apparently, have no need for such information. Of the remaining 73% of boaters who receive status information, 36% (categories 2-4) rely on marine radio broadcasts and/or radio communications with local USCG stations, 3% on printed local Notices to Mariners only, and 15% (category 6) on local Notices to Mariners in combination with the marine radio broadcasts and/or radio communications with local USCG stations. Similarly, 1% depend on printed weekly Notices to Mariners only, 3% (category 8) on weekly Notices to Mariners in combination with marine radio broadcasts and/or radio communications with local USCG stations, and 6% (category 9) on weekly and local Notices to Mariners in combination with marine radio broadcasts and/or radio communications with local USCG stations. Finally, 1% of boaters rely on charts only and 8% on a variety of sources, including those listed above. The latter are an amalgam of boaters who have been

lumped together because of their small size of less than 1% each. A combination of sources was used including those already listed, the automated Notices to Mariners, subscription magazines and other printed matter, NAVTEX messages, electronic bulletin board services and so on.

TABLE 4-22

SOURCES OF STATUS INFORMATION ON NAVAIDS

SOURCE(S) USED	%	CUMULATIVE %
1. Do no get any status information	27	27
2. Marine radio broadcasts only	19	46
3. Radio communications with local USCG + (2)	15	61
4. Radio communications with local USCG only	2	63
5. Local Notices to Mariners only	3	66
6. Local Notices to Mariners + (2 and/or 4)	15	81
7. Weekly Notices to Mariners only	1	82
8. Weekly Notices to Mariners + (2 and/or 4)	3	85
9. Weekly & Local Nots to Mariners + (2 and/or 4)	6	91
10. Charts only	1	92
11. Other sources, including the above	8	100
		(5042)

4.5.10 CHARTS USAGE

The respondents were asked to specify the percent of the total boating time in which charts were used.

4.5.10.1 Use of Charts In Total Boating Time: Data on the extent to which charts are used indicates that 82% of boaters use paper charts for varying amounts of boating time, while only 9% use electronic charts (see Figure 4-13). Among users of paper charts, almost 32% of boaters may be labelled heavy users during 75-100% of boating time, 13% as medium users during 50-74% of boating time, 27% as light users during 10-49% of boating time and 10% as

occasional users during less than 10% of boating time. As for users of electronic charts, all 9% of boaters are occasional users.

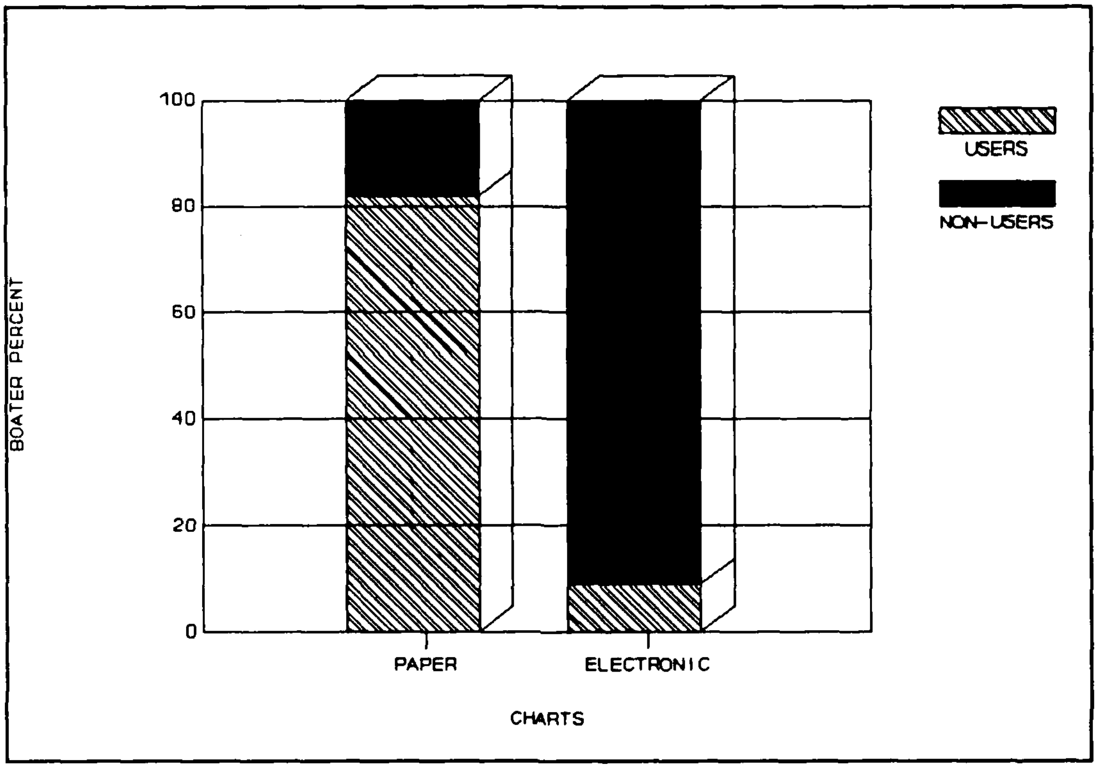

FIGURE 4-13. Charts Usage Rate

4.5.11 <u>ELECTRONIC FIXTURES ON BOARD</u>

For information on electronic equipment installed on the boats, the respondents were asked to specify the electronic equipment (other than the radionavigation receivers) used on board.

4.5.11.1 <u>Fixtures Installed</u>: The most extensively installed electronic fixture is the communication equipment, found on 91% of the boats (see Figure 4-14). Among the communications equipment, the most prevalent is the VHF-FM equipment, with 87% of the boats equipped with VHF-FM transceivers and 4% with receivers only. The statistics of other communications equipment are somewhat unreliable since 81% of boaters equipped with communications

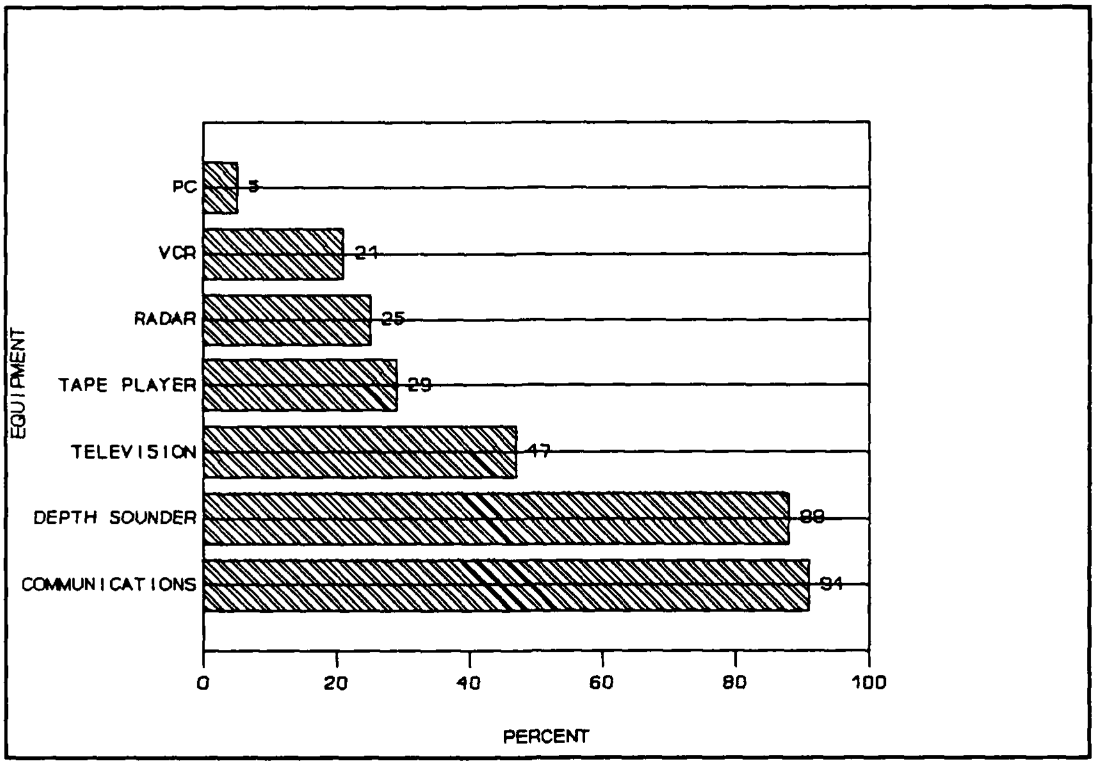

FIGURE 4-14. Electronic Fixtures on Board

equipment did not answer and presumably do not have additional communications equipment. Only 9% of boats with any communications equipment indicated they have HF-SSB transceivers and 1% receivers only. Similarly, 11% of boats that have communications equipment indicated they also have CB radios, about 2% SW-Band radios and 1% cordless phones.

The second most extensive electronic fixture is the depth sounder, installed on 88% of boats. Other fixtures, however, are found with much less frequencies. Of particular note are televisions on 47% of boats, tape players on 29%, radar on 25%, video cassette recorders on 21% and personal computers on 5%. Finally, about 3% of boats do not have any electronic fixtures on board.

4.6 BOATER COMMENTS: VIEWS ON RADIONAVIGATION SYSTEMS, USCG, AND SURVEY

The respondents were invited at the end of the questionnaire to give their comments or any additional information in the blank space provided.

4.6.1 Respondent General Comments: Nearly 83% of respondents did not make any comments; of the 17% who did, their comments are summarized as follows: 5% favored keeping LORAN-C with GPS, 3% stated they had no need for complex radionavigation or any other electronic equipment, 2% were highly complimentary of the USCG, 2% said they liked GPS, 1% desired more information from the USCG about RNSs, 1% stated that current RNSs provided inadequate coverage, 1% favored keeping LORAN-C and also liked GPS, and 1% were critical of USCG for one reason or another. The remaining 1% gave a combination of comments discussed above, including that LORAN-C is inadequate and that survey results should be shared with them.

4.7 SOME CONCLUDING REMARKS

The USCG survey of registered and documented boat operators has provided empirical data on boaters' appraisal of current RNSs, their predisposition towards more accurate systems, receiving system attributes and purchase plans, and boating characteristics. The survey findings reveal an underlying boater attitude that most small craft operators do not require high accuracy in navigation. Boaters, therefore, find current systems, especially the LORAN-C system, adequate for their needs. Accordingly, their attitudes towards future RNSs are based on the belief that little or no additional benefits are to be derived from more accurate satellite-based systems. These attitudes have, in turn, shaped their preferences and requirements, as discussed above. As a result, GPS has a small base of support among small craft operators.

Among the salient findings discussed above, some are especially noteworthy:

A. The average period of boat ownership is approximately 8 years and there is a substantial secondary market for boats.

B. Almost half (48%) the boats, or an estimated 230,043 out of a possible universe of 480,287 boats that are 26 feet and above in length overall, do not have any receivers on board and, presumably, do not use any radionavigation system.

C. About 44% of boats or an estimated 211,110 boats use LORAN-C exclusively or in combination with other systems.

D. There are virtually no Omega system users as evidenced by the very small number (less than 0.3%) of boats that are equipped with Omega receivers.

E. About 75% of boats are used exclusively for recreation.

F. Boaters are not interested in very precise position accuracies. On average, in open ocean the specified accuracy is 2 nautical miles, in coastal waters 563 meters, and in inland waters 245 meters.

G. Whereas the LORAN-C and Transit systems are more intensively used than the Radiobeacons system by boaters in open ocean and coastal waters, the LORAN-C system also has a higher use rate in inland waters, lakes and rivers, and Great Lakes.

H. The average yearly savings from using the RNSs are small. The highest average savings are attributed to the use of LORAN-C and those are 153 gallons in fuel and 39 hours in time per year.

I. Over a quarter of boaters showed no interest in differential LORAN-C service even when freely provided by the government.

J. Knowledge and interest in future satellite-based RNS is lacking among boaters, generally speaking.

K. On average, the amount a boater will spend on a new GPS receiver is approximately $1,561.

L. As boaters prefer, the average transition period from the current RNSs to GPS is nine years for the LORAN-C and Radiobeacons

systems, five years for the Transit and four years for the Omega system. The highest median transition period, on the other hand, is four years for LORAN-C.

M. Over a quarter of boaters (27%) do not receive and use status information. About 60% listen to marine radio broadcasts and/or rely on radio communications with local USCG stations for status information. Only 28% of boaters use printed local or weekly Notice to Mariners. Note that the latter two percentages contain some overlapping users of both radio and printed sources.

The findings reported above do not give any indication of which stratum and class of boaters had what preferences, which characteristic correlates with another or how much. The answers to such analytical and other questions can be obtained by further analysis of the survey data.

5. MERCHANT VESSELS

The merchant vessel questionnaire was targeted at U.S. parent companies (operators, for short) operating directly or through a subsidiary U.S. owned and U.S. flagged or U.S. owned and foreign flagged ships. It was designed to gather data on: the merchant vessel operators' appraisal of current radionavigation systems (RNSs), their predisposition towards the proposed more accurate systems, receiver attributes, the pattern of usage of sources for RNS status information and the electronic fixtures installed on the vessels. To give an overview of the survey findings, the mean characteristics are delineated first, followed by the enumeration of receiver population projections.

5.1 MEAN CHARACTERISTICS AND RECEIVER POPULATION PROJECTIONS

The mean characteristics and receiver population projections are given separately in sections 5.1.1 and 5.1.2, respectively.

5.1.1 MEAN CHARACTERISTICS

Computed mean characteristics of merchant vessels are reported below for a selected number of variables: RNS usage, signal quality, savings attributed to the use of RNS, accuracy requirements, transition periods to GPS, and highest purchase price for other than current receiver.

RNS Usage:[1]	Radiobeacons	Transit	LORAN-C
Open Ocean	14% ± 5%	86% ± 4%	52% ± 6%
Coastal Waters	18% ± 4%	63% ± 7%	75% ± 5%

RNS Problems:[1]			
No Signal	39% ± 7%	9% ± 3%	16% ± 4%
Weak Signal	29% ± 6%	5% ± 2%	14% ± 3%
Interference	32% ± 7%	3% ± 1%	11% ± 2%

Savings Due To RNS:	Radiobeacons	Transit	LORAN-C
Fuel (in gal)	*	19,326 ± 6,688	14,207 ± 8,155
Time (in hours)	*	53 ± 19	50 ± 28
RNS Transition (in years):	7 ± 3	7 ± 2 (Omega: 1 ± .4)	8 ± 2

RNS Accuracy Desired:		
	Open Ocean	2 nm ± .4 nm
	Coastal Waters	791 m ± 172 m
	Inland Waters	207 m ± 75 m

Highest Receiver Purchase Price for Boat (in dollars):

More Accurate Replacement Unit	$7,929 ± 3,791
GPS Unit	8,455 ± 1,447
Differential GPS Unit	8,315 ± 3,427
GEOSTAR Unit	7,154 ± 1,718
STARFIX Unit	7,174 ± 2,707
STARFIND Unit	9,286 ± 4,918

* not stated due to small number of users in sample returns
nm = nautical miles m = meters

[1]As percent of total boating time

Note that some standard errors reported above are high due to small sample size for the measured characteristic and/or large standard deviation generated by some extreme values of the characteristic.

5.1.2 RECEIVER POPULATION PROJECTIONS

All the 1,248 merchant vessels, constituting the survey population, that are privately owned by U.S. companies and operated under the U.S. or foreign flags had radionavigation equipment. The receiver projections, and corresponding standard errors at 95% level of confidence, are given below.

A. Radio Direction Finder: An estimated 1,087 vessels are equipped with the Radio Direction Finder (RDF) receivers, with a standard error of ± 59 vessels. The estimated number of receivers on these vessels are 1,094, with a standard error of ± 60 receivers. The distribution of RDF receivers by units is given in Table 5-1.

TABLE 5-1

DISTRIBUTION OF RDF RECEIVERS

Units		Vessels	Number of Receivers
1		1,080	1,080
2		7	14
	TOTAL	1,087	1,094

B. Omega Receivers: There are an estimated 148 vessels equipped with Omega receivers, each with one receiver unit. The standard error for both vessels and receivers is ± 62 which is relatively large because the projection is based on a very small number of vessels in the sample.

C. Transit Receivers: The population of merchant vessels equipped with Transit receivers is estimated to be 1,019, with a standard error of ± 66 vessels. The receivers are estimated to number 1,063, with a standard error of ± 69 units. The

distribution of receivers by units is given in Table 5-2.

TABLE 5-2

DISTRIBUTION OF TRANSIT RECEIVERS

Units		Vessels	Number of Receivers
1		975	975
2		44	88
	TOTAL	1,019	1,063

D. LORAN-C Receivers: There are altogether an estimated 1,084 vessels equipped with LORAN-C receivers. The standard error for this estimate is ± 59 vessels. An estimated 1,202 receivers are installed on the LORAN-C equipped vessels, with a standard error of ± 65 receivers. The distribution of LORAN-C receivers is given in Table 5-3.

TABLE 5-3

DISTRIBUTION OF LORAN-C RECEIVERS

Units		Vessels	Number of Receivers
1		988	988
2		74	148
3		22	66
	TOTAL	1,084	1,202

E. Decca Receivers: Vessels equipped with Decca are projected to number 288, as are receivers since each vessel has one Decca receiver only. The standard error for the estimate is ± 76 vessels and receivers, respectively.

The estimate for vessels equipped with GPS are not given here because only a very small number of vessels in the sample have GPS receivers. Projections based on such a small sample would be unreliable.

5.2 CURRENT RADIONAVIGATION SYSTEMS: SYSTEM USAGE, COVERAGE, BENEFITS, AND PHASE-OUT PERIOD

The merchant vessel questionnaire contained a series of questions on current radionavigation systems. The response would provide user feedback to the USCG on: systems used and usage rate, system coverage and accuracy, system benefits and problems, and user preferences for the phase-out period of current systems as GPS became operational. The salient findings are reported below.

5.2.1 SYSTEMS AND USAGE

The merchant vessel respondents were asked to specify the type and number of receivers installed in their vessels and the percent of the time they utilized the various radionavigation systems in different waters.

5.2.1.1 Systems Used: Merchant vessels exhibit some consistency in the radionavigation systems they use as evidenced by the receivers they carry. As Figure 5-1 indicates, more than four-fifths of merchant vessels are equipped with receivers of three types: 87% of vessels have RDF and LORAN-C, and 82% Transit receivers. For other types of receivers, however, the vessel statistics vary considerably: only 23% vessels are equipped with Decca, 12% with Omega and approximately 1% with GPS receivers. The survey data on the system most used by vessels (87%) carrying more than one type of receiver shows an overwhelming preference for Transit by 67% vessels, followed by LORAN-C by 19% and Decca by 1%.

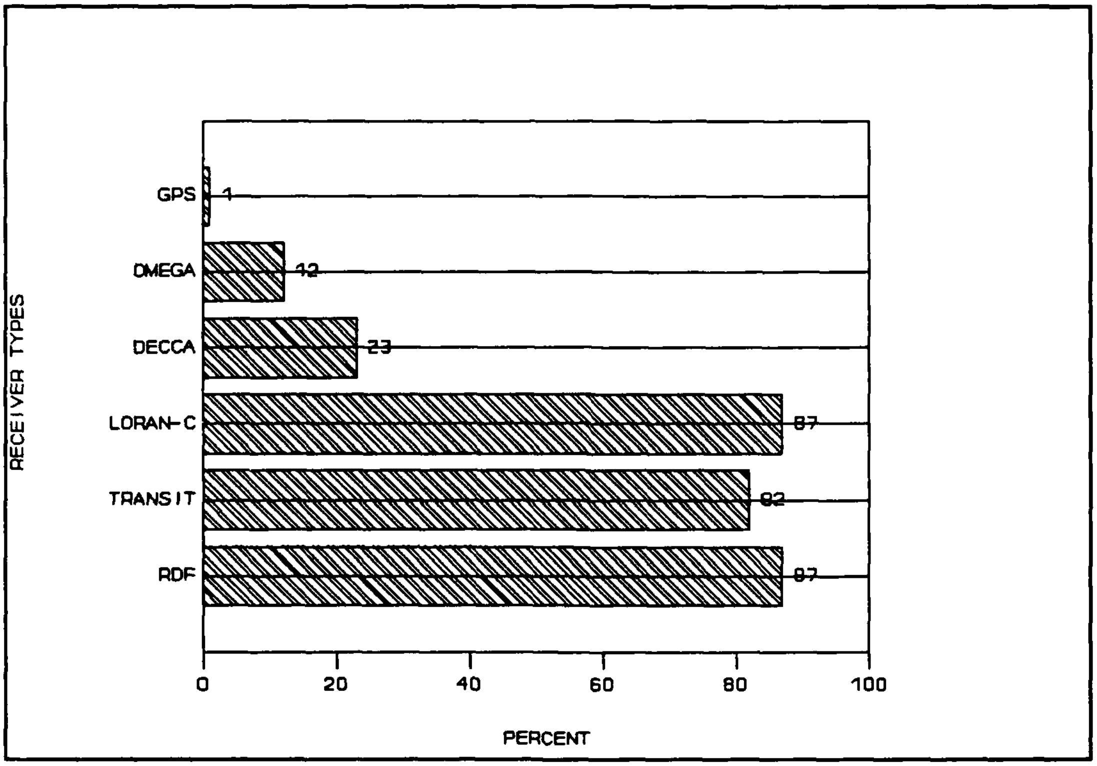

FIGURE 5-1. RNS Receiver Types on Board Vessels

5.2.1.2 Incidence of RNS Utilization: The Radiobeacons system is not much used by the merchant vessels in any waters; in contrast, the Transit and LORAN-C systems are used quite intensively in certain waters. Specifically, as Table 5-4 indicates, the percentage of vessels using Radiobeacons for 50% or more of the underway time are: 13% in open oceans, 17% in coastal waters, 8% in inland waters and 11% in the Great Lakes. The incidence of Omega usage, also for 50% or more of the underway time, is slightly higher: 30% in open oceans, 23% in coastal waters, 16% in inland waters and none in the Great Lakes. On the other hand, vessels using Transit in different waters for 50% or more of the underway time are: 91% in open oceans, 64% in coastal waters, 37% in inland waters and 19% in Great Lakes. Similarly, vessels using LORAN-C for 50% or more of the underway time are:

54% in open oceans, 86% in coastal waters, 52% in inland waters and 60% in the Great Lakes.

TABLE 5-4

INCIDENCE OF RNS USAGE IN DIFFERENT WATERS

SYSTEM	USE RATE	OPEN OCEANS	COASTAL WATERS	INLAND WATERS	GREAT LAKES
Radiobeacons	50%+	13%	17%	8%	11%
		(67)	(95)	(37)	(16)
Omega	50%+	30%	23%	16%	0%
		(16)	(13)	(6)	(3)
Transit	50%+	91%	64%	37%	19%
		(128)	(114)	(43)	(12)
LORAN-C	50%+	54%	86%	52%	60%
		(107)	(114)	(41)	(19)

NOTE: Each cell value is unrelated to any other column or row cell value because of overlap of vessels.

5.2.2 COVERAGE AND ACCURACY

In the merchant vessel questionnaire, the respondents were asked to rate the transmitted signal coverage and also the radionavigation system accuracy.

5.2.2.1 RNS Coverage: More merchant vessel operators report adequate coverage for the Omega, Transit and LORAN-C systems than for the Radiobeacons system. Figure 5-2 shows that over four-fifths (89%) of Transit users, over three-fourths (77%) of LORAN-C users and nearly three-fourths (72%) of Omega users report the system coverage to be adequate; in contrast, only half (51%) of Radiobeacons users acknowledge that coverage is adequate.

5.2.2.2 Accuracy Requirements: The merchant vessel operators have high accuracy requirements in all waters except the coastal

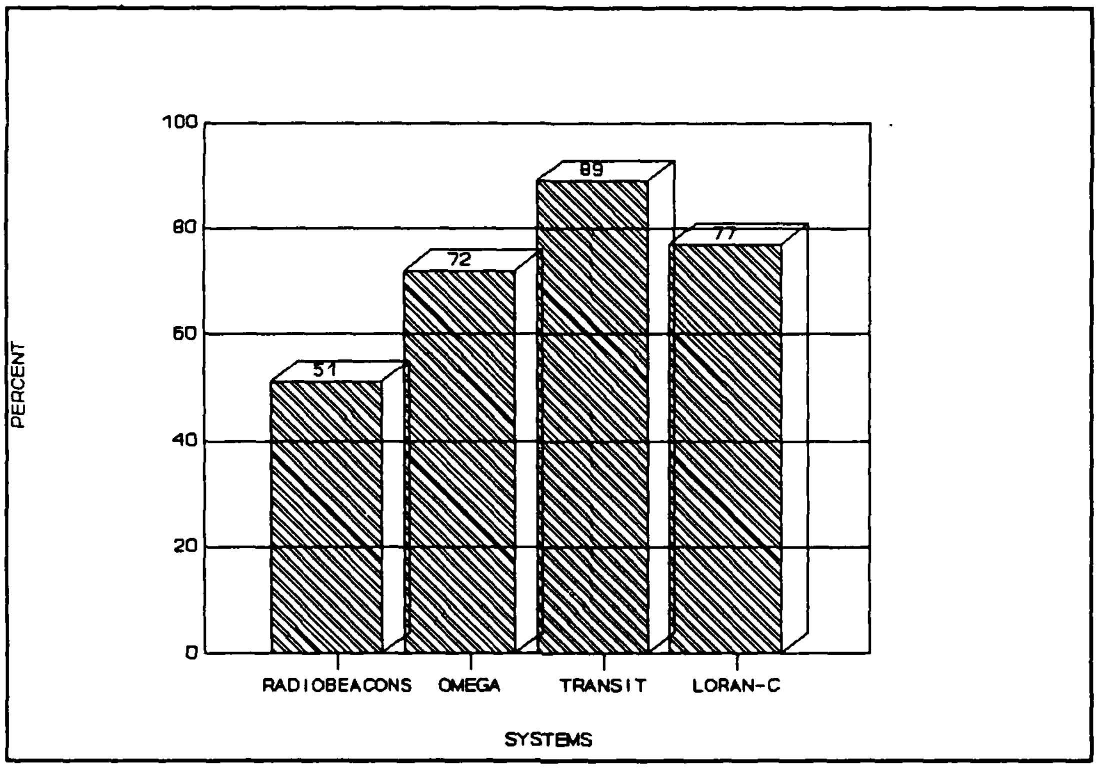

FIGURE 5-2. Systems Ratings for Adequacy of Signal Coverage

waters. In the latter, the primary interest of operators is, apparently, direction rather than position,hence accuracy requirements are less stringent than in other waters. As Table 5-5 indicates, the modal accuracy requirement categories in different waters are as follows: 29% merchant vessel operators preferred accuracy between 0.76-1.00 nautical miles in open oceans, 27% between 901-1000 meters in coastal waters, 23% between 91-100 meters in inland waters and 23% between 21-30 meters in the Great Lakes. The median accuracy requirements are: approximately 1 nautical mile in open oceans, 467 meters in coastal waters, 93 meters in inland waters and 41 meters in the Great Lakes.

TABLE 5-5

ACCURACY REQUIREMENTS IN DIFFERENT WATERS

ACCURACY CATEGORY	PERCENT	CUMULATIVE PERCENT
	Open Ocean	
0.01 - 0.25 nm	13	13
0.26 - 0.50	12	25
0.51 - 0.75	3	28
0.76 - 1.00	29	57
1.01 and above	43	100
		(127)
	Coastal Waters	
1 - 100 m	23	23
101 - 200	13	36
201 - 300	1	37
301 - 400	7	44
401 - 500	9	53
501 - 600	2	55
601 - 700	1	56
701 - 800	1	57
801 - 900	0	57
901 - 1000	27	84
1001 and above	16	100
		(131)

TABLE 5-5 (cont'd)

ACCURACY CATEGORY	INLAND WATERS	GREAT LAKES
01 - 10 m	10%	16%
11 - 20	8	6
21 - 30	8	23
31 - 40	4	4
41 - 50	7	7
51 - 60	0	0
61 - 70	0	0
71 - 80	6	0
81 - 90	0	0
91 - 100	23	10
101 - 200	12	11
201 and above	22	23
	100	100
	(78)	(29)

5.2.2.3 Satisfaction Rating of RNS Accuracy: Among the merchant vessel operators, only about two-thirds (66% of Radiobeacons and 68% of Omega users) state that they are either very satisfied or somewhat satisfied with the accuracies of those systems; in contrast, all (100%) Transit and nearly all (96%) of LORAN-C users are satisfied (see Figure 5-3).

5.2.3 BENEFITS AND PROBLEMS

The USCG is interested in the user feedback from the merchant vessel operators on their rating and valuation of benefits received from the use of RNSs and also the extent of navigation problems encountered. The survey addressed a series of questions on these issues to the respondents.

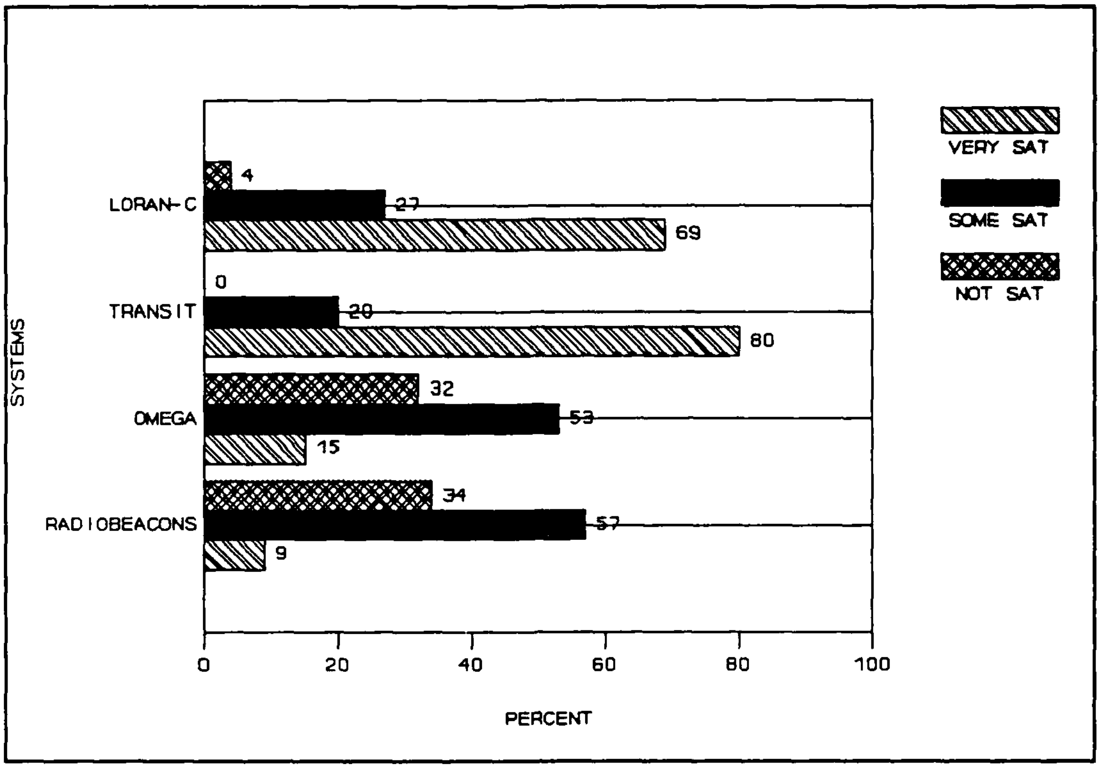

FIGURE 5-3. Satisfaction Rating of RNS Accuracy

5.2.3.1 RNS Benefits Rating: The merchant vessel users of RNSs rated the benefits of RNS as follows: 96% rated RNS as being very important or somewhat important to improving navigation safety, 89% to saving time, 94% to saving fuel and 89% to savings in indirect cost (see Figure 5-4).

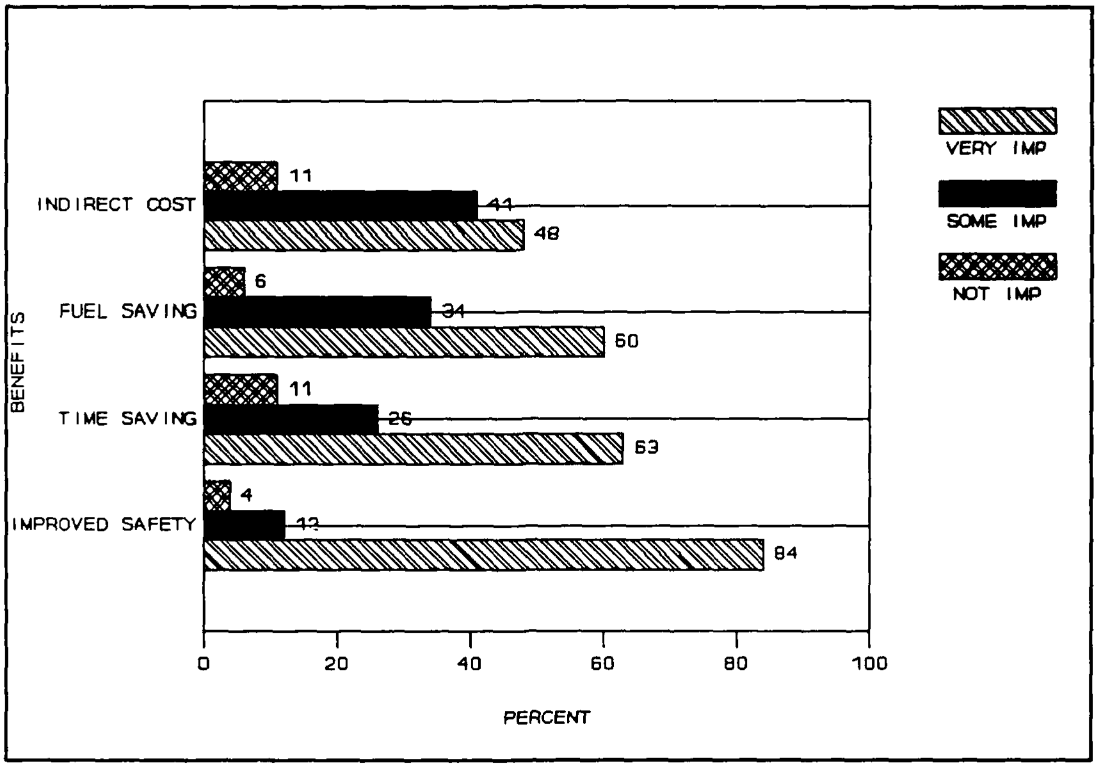

FIGURE 5-4. Rating the Importance of RNS Benefits

5.2.3.2 Savings Attributed to RNS: The merchant vessel operators generally (95%) report no fuel or time savings from using the Radiobeacons system (see Table 5-6). In contrast, only approximately a third of operators attribute no savings to the Transit (27-29%) and LORAN-C (37-38%) systems. The other two-thirds, however, acknowledge varying amounts of fuel and time savings. For instance, 22% of Transit users and 38% of LORAN-C users claim annual fuel savings of up to 10,000 gallons, and 23% and 10% respectively report savings of 10,001-20,000 gallons. Fewer Transit and LORAN-C (0-10%) claim higher savings. Similarly, annual time savings of up to 100 hours are reported by 63% of Transit and 49% of LORAN-C users. In contrast, only 7% or less users of both systems report higher time savings. The median annual savings, inclusive of the zero savings category, are: 9,545 gallons and 37 hours for Transit, and 3,158 gallons and 27 hours

for LORAN-C users. The Omega savings data is not discussed because of the small number of users in the sample returns.

TABLE 5-6

ANNUAL SAVINGS ATTRIBUTED TO RADIONAVIGATION SYSTEMS

	RADIOBEACONS	OMEGA	TRANSIT	LORAN-C
Fuel Savings (gallons)				
0	95%	68%	29%	38%
1 - 10,000	5	16	22	38
10,001 - 20,000	0	0	23	10
20,001 - 30,000	0	16	8	2
30,001 - 40,000	0	0	5	2
40,001 - 50,000	0	0	5	0
50,001 and above	0	0	8	10
	100	100	100	100
	(44)	(6)	(50)	(51)
Time Savings (hours)				
0	95	53	27	37
1 - 100	5	23	63	49
101 - 200	0	0	5	5
201 - 300	0	0	3	7
301 - 400	0	24	2	0
401 - 500	0	0	0	0
501 and above	0	0	0	2
	100	100	100	100
	(39)	(4)	(53)	(54)

5.2.3.3 RNS Problems: The data (see Table 5-7) on signal loss, weakness and interference reveals three broad tendencies: (1) more users of Transit (26-55%) followed by LORAN-C (11-17%) report no signal problems than users of Radiobeacons (6-10%), (2) relatively fewer users of Radiobeacons (36-51%) report signal

problems during 1-20% of boating time than users of Transit (45-63%) and of LORAN-C (58-73%) and (3) relatively fewer users of Transit (0-11%) followed by LORAN-C (10-26%) experience signal problems during 21-100% of boating time than users of Radiobeacons (43-54%). The reasons for these inconsistent tendencies are not clear at this time and require further analysis of data. The Omega signal problems are not included in the above analysis because of the small number of Omega users in the sample returns.

TABLE 5-7

INCIDENCE OF RNS PROBLEMS ENCOUNTERED

BOATING TIME	RADIOBEACONS	OMEGA	TRANSIT	LORAN-C
		Signal Loss		
0%	10%	40%	26%	16%
1 - 20%	36	39	63	58
21 - 100%	54	21	11	26
	100	100	100	100
	(86)	(10)	(81)	(87)
		Signal Weakness		
0%	6%	23%	40%	11%
1 - 20%	51	39	58	67
21 - 100%	43	38	2	22
	100	100	100	100
	(81)	(13)	(56)	(90)
		Interference		
0%	10%	40%	55%	17%
1 - 20%	40	23	45	73
21 - 100%	50	37	0	10
	100	100	100	100
	(63)	(8)	(51)	(82)

5.2.4 PHASE-OUT PERIOD

To assess user preferences for the phase-out period of current RNSs, the respondents were asked to specify the number of years the current systems ought to remain available after the GPS became fully operational.

5.2.4.1 Transition Periods from Current RNSs to GPS: Generally, the merchant vessel respondents expressed a preference for phasing out the current systems gradually. With one exception, as Table 5-8 shows, the modal category for the transition period from current RNSs to GPS is 1-5 years, is preferred by 42% of respondents for the Radiobeacons, 70% for the Transit and 65% for the LORAN-C systems. The Omega system is the lone exception with a modal transition period of 0 years preferred by 68% of respondents. The median transition year, on the other hand, was as follows: 1 year for Radiobeacons, 3 years for Transit and 4 years for LORAN-C systems. Note that the transition period for all RNSs was capped at 50 years maximum.

TABLE 5-8

PHASE-OUT PERIOD FOR CURRENT RADIONAVIGATION SYSTEMS

YEARS	RADIOBEACONS	OMEGA	TRANSIT	LORAN-C
0	41%	68%	4%	2%
1 - 5	42	30	70	65
6 - 10	5	2	19	21
11 and above	12	0	7	12
	100	100	100	100
	(91)	(55)	(125)	(125)

5.3 PROPOSED RADIONAVIGATION SYSTEMS: AN ASSESSMENT OF MERCHANT VESSEL OPERATOR PREDISPOSITION TOWARDS MORE ACCURATE SYSTEMS

The merchant vessels currently rely on radionavigation systems that do not provide high accuracy or frequency of position on the high seas. More accurate and continuous service is available, however, in the coastal and inland waters. The proposed satellite-based systems, in contrast, will provide highly accurate and continuous position fixes in all waters. The USCG is, therefore, interested in knowing the disposition of merchant vessel operators towards more accurate systems in general and satellite-based systems in particular.

5.3.1 DIFFERENTIAL LORAN-C

The questionnaire noted that the differential LORAN-C service could provide an accuracy of less than 20 meters to properly-equipped users within the reference stations' radius of approximately 50 miles. It asked the respondents if such a service were to be provided by the government freely, would they purchase a new receiver, modify an existing receiver, or rather not use the service?

5.3.1.1 Reaction to Free Differential LORAN-C Service: The prospect of free differential LORAN-C service did not evoke an enthusiastic response for the purchase of new differential receivers from a large segment of merchant vessel operators. Only 19% of the operators responded with an outright commitment to buy new differential receivers (see Figure 5-5). In contrast, 39% stated they would be unlikely users of the service, and 42% opted to modify the currently installed LORAN-C receivers.

5.3.2 GLOBAL POSITIONING SYSTEM

The USCG wants feedback on the level of awareness and the rating of benefits of higher GPS accuracy relative to any current RNS. Accordingly, the respondents were asked to specify their

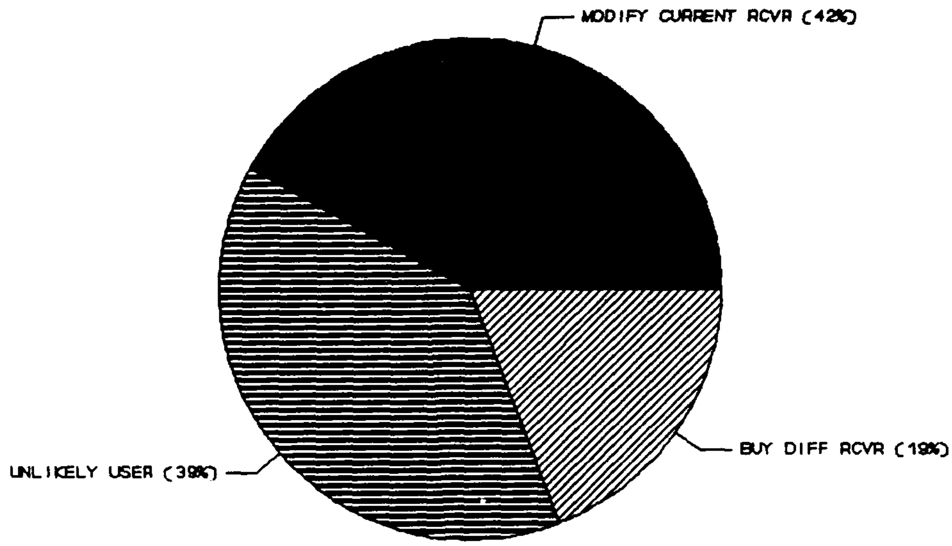

FIGURE 5-5. Reaction to Differential LORAN-C Free Service

level of familiarity with GPS and to state whether the planned GPS accuracy of 100 meters in all waters would benefit them.

5.3.2.1 Familiarity with GPS: A majority of merchant vessel operators are familiar with GPS: 61% are informed through exposure to the literature on GPS but have no experience, and 8% have some operational experience (see Figure 5-6). However, almost one-third (31%) of the operators are still unfamiliar, reporting no knowledge or experience with the GPS.

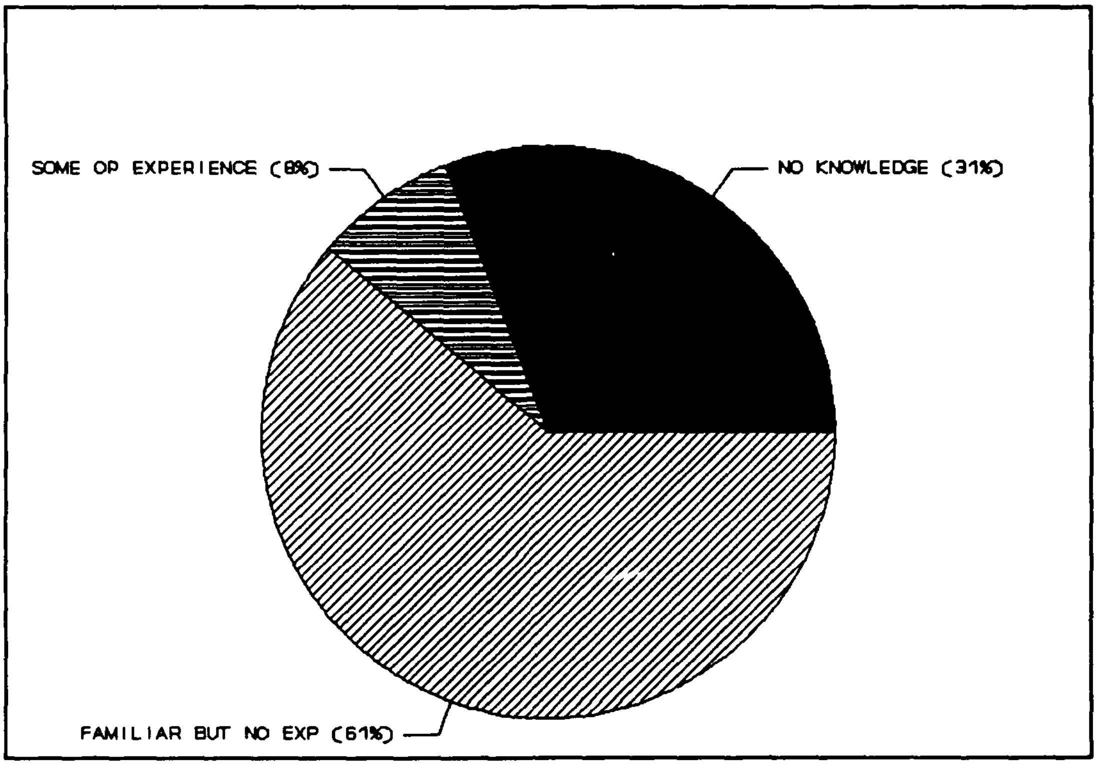

FIGURE 5-6. Familiarity with GPS

5.3.2.2 Benefit from Increased GPS Accuracy: As shown in Table 5-9, 82% of the respondents acknowledged they would benefit from increased GPS positional accuracy of 100 meters; only 18% stated they would not.

TABLE 5-9

GPS ACCURACY* VIEWED AS POTENTIAL BENEFIT

RESPONSE	PERCENT	CUMULATIVE PERCENT
Will benefit from GPS accuracy	82	82
Will not benefit	18	100
		(161)

*100 meters or better horizontally

5.3.3 DIFFERENTIAL GLOBAL POSITIONING SYSTEM

Continuing the line of inquiry on user predisposition towards more accurate systems, the survey asked the respondents for their reaction to the differential GPS, freely provided by the government, which would have an improved accuracy of less than 20 meters in an extended coverage area of 100-mile radius. The respondents were asked to indicate whether they would purchase a differential GPS receiver, modify an installed GPS receiver to accept differential corrections, or be unlikely users.

5.3.3.1 Reaction to Differential GPS: Given the desire for more accuracy among merchant vessel operators, it was surprising that over half (51%) of respondents indicated they would be unlikely users of the differential GPS (See Figure 5-7). However, over a third (34%) of the respondents declared their commitment to buy a differential GPS receiver, and only 15% opted to modify an installed GPS receiver.

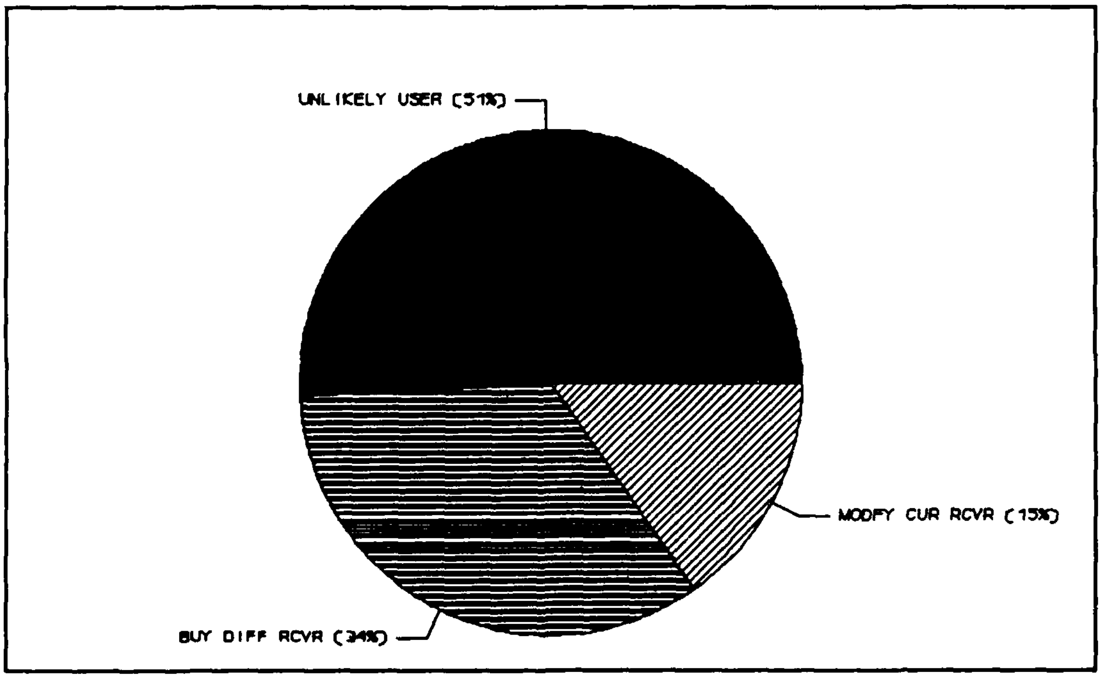

FIGURE 5-7. Reaction to Differential GPS Free Service

5.3.4 PRECISE POSITIONING SERVICE

The questionnaire noted that another more accurate system, the PPS with an accuracy of 20 meters or less, could also be available for a fee to the merchant marine community provided they could show a valid need for the service, had exhausted alternative sources and could give evidence that the use of PPS would be in the national interest. The respondents were asked if they required access to PPS under these conditions.

5.3.4.1 Access to PPS: A majority of respondents indicated no interest in or were not sure about the need to use the PPS; a small minority, however, reacted favorably to the availability of PPS. As Table 5-10 shows, over half (51%) of the respondents said they did not require access to PPS, and about one-third (31%) stated they were not sure whether they would. Less than one-fifth (18%) of respondents declared they intended to use PPS, if it were available.

TABLE 5-10

MERCHANT VESSEL OPERATORS REQUIRING ACCESS TO PPS

RESPONSE	PERCENT	CUMULATIVE PERCENT
PPS access not required	51	51
Not sure	31	82
PPS access required	18	100
		(158)

5.3.5 PRIVATE SATELLITE-BASED SYSTEMS

The survey also asked the respondents to indicate their familiarity with and the need for planned accuracy of some better-known private satellite-based systems.

5.3.5.1 Familiarity with Private Satellite-based Systems: The merchant vessel users of RNS are, relatively speaking, more

familiar with GEOSTAR than with STARFIX or STARFIND. As shown in Table 5-11, more than one-third (37%) stated that they were either very familiar or somewhat familiar with GEOSTAR, as against about one-fifth stating they were familiar with STARFIX (21%) and STARFIND (20%).

TABLE 5-11

FAMILIARITY WITH PRIVATE SATELLITE-BASED SYSTEMS

FAMILIARITY LEVEL	GEOSTAR	STARFIX	STARFIND
Not Familiar	63%	79%	80%
Somewhat Familiar	33	19	18
Very Familiar	4	2	2
	100	100	100
	(153)	(152)	(157)

5.3.5.2 Need for Planned Accuracy of Private Satellite-based Systems: A preponderance of merchant vessel operators affirmed their interest in the planned accuracies of private satellite-based radionavigation services. As for the planned accuracy of 100 meters for GEOSTAR, 84% stated it would certainly meet their accuracy requirements (see Table 5-12). Next, about 80% acknowledged their interest in the higher planned accuracy of 10 meters for STARFIX, and an equal number in the highest planned accuracy of 6 meters for STARFIND.

TABLE 5-12

MERCHANT VESSEL OPERATORS SIGNIFYING NEED FOR ACCURACY OF PRIVATE SATELLITE-BASED SYSTEMS

	GEOSTAR (100 m)	STARFIX (10 m)	STARFIND (6 m)
Yes	84%	80%	80%
No	16	20	20
	100	100	100
	(111)	(86)	(84)

5.4 RECEIVING SYSTEMS: CURRENT UNIT(S) AND REPLACEMENT PRICING AND PLANS

The survey respondents were asked several questions on receiving system characteristics: how many receivers were installed on the vessels; how would they rate the receivers for accuracy; what were the typical receiver applications for navigation; what receiver type did they plan to purchase in the next two years; and what price would the respondents pay for more accurate replacement receiver units? The salient findings are reported below.

5.4.1 UNITS INSTALLED

To determine the distribution of shipboard receivers, the respondents were asked to specify the number of units installed in their vessels.

5.4.1.1 Number of Receivers Installed: About 13% of vessels are equipped with only one type of receiver and 87% with more than one type (see Figure 5-8). The latter include: 15% equipped with two receiver types, 46% with three, 22% with four and 4% with five receiver types. Among one receiver type vessels, nearly 3% have RDF and 10% LORAN-C receivers only. The multiple receiver type vessels, on the other hand, have a varied mix of RDF, LORAN-C, Omega, Transit, Decca and GPS receivers.

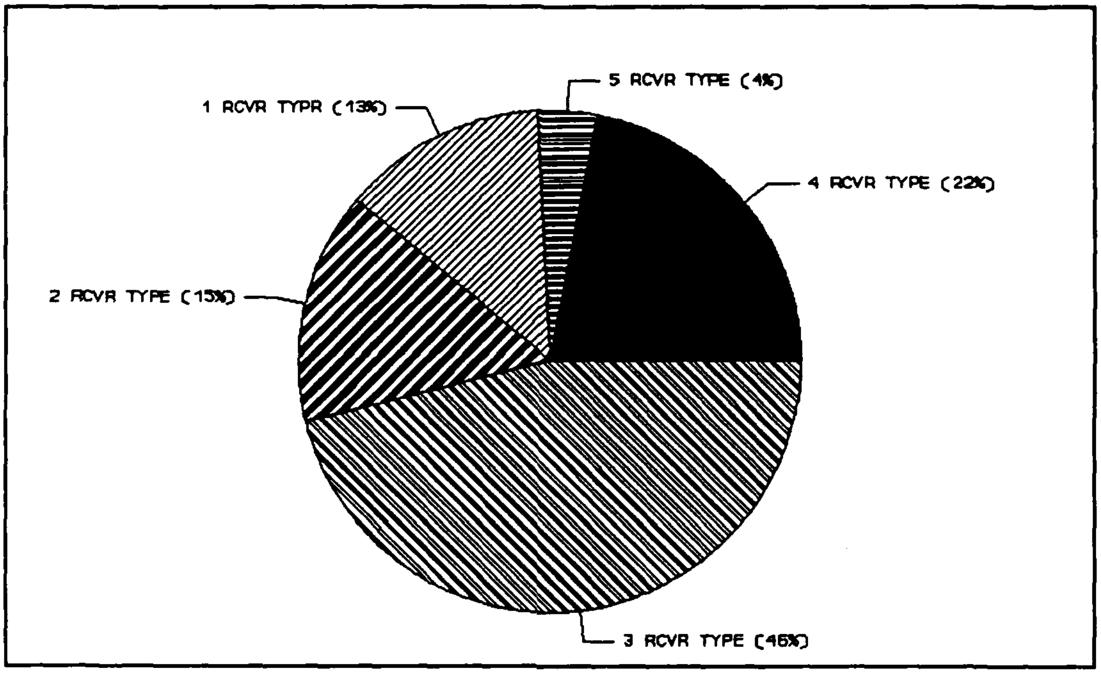

FIGURE 5-8. Grouping Vessels by Receiver Types

5.4.2 RECEIVER APPLICATIONS

The information on receiver applications was solicited in two parts: how the receivers are used and what is the primary usage, if receivers have multiple applications.

5.4.2.1 Receiver Information Applications: As Table 5-13 shows, the use of receivers by merchant vessel operators for information on direction, position, range, etc. exhibits the following pattern:

1. About 45% of the operators report multiple applications for their RDF receivers, namely, for direction finding as well as position fixes. Between these two applications, 23% of the vessel operators say the primary use of RDFs is direction finding and 22% position fixes. Among 55% operators reporting single application, more

TABLE 5-13

RECEIVER APPLICATIONS

INFORMATION	RADIOBEACONS	OMEGA	TRANSIT	LORAN-C
Direction only	26%	na	na	na
Position only	29	95	53%	91%
PTTI only	na	0	1	1
Various combinations	45	5	46	8
	100	100	100	100
	(135)	(18)	(138)	(143)

na = not applicable

than a quarter (29%) report getting position fixes by reading two or more bearing angles, and another quarter (26%) by receiving homing or direction information by reading one bearing angle.

2. Only 5% of the operators report multi-purpose applications of Omega receivers to obtain position and precise time and time interval. In contrast, 95% claim single-purpose use to obtain position only: 40% to obtain position (latitude/longitude) from receiver display, 18% to read phase differences and plot those on a chart to get position, 25% do both and 12% to obtain position from receiver display and also steer to a waypoint stored in the receiver.

3. Nearly 46% of the operators indicate multi-purpose applications of Transit receivers for obtaining positions from receiver displays, PTTI and waypoints. The primary application is to obtain positions from receiver displays. For 54% of the operators reporting single application of the Transit receivers, on the other hand, the receivers are used mainly to obtain positions (53%) and marginally PTTI (1%).

4. Only 8% of the operators report multi-purpose use of LORAN-C receivers for determining position, PTTI and boat speed. In contrast, 92% make single-purpose use of receivers: 91% for determining position and 1% for PTTI. As for techniques employed to determine position, 61% use receivers in normal mode only (29% to obtain positions from receiver displays, 21% read TDs and plot these on a chart to get a position, and 11% do both), 1% use repeatable mode only, 1% use rho-rho mode only and the remaining 36% of the operators use a combination of normal, repeatable and rho-rho modes. Among the latter, the primary application of LORAN-C receivers is as follows: 27% of the operators use receivers in normal mode primarily and 9% in the repeatable mode.

5.4.3 RECEIVER PERFORMANCE

The USCG wishes to know how the survey respondents rate the accuracy of their current shipboard receivers and what are their price preferences for more accurate replacement units as well as their purchase plans.

5.4.3.1 Rating the Accuracy of Current Receiver(s): Most merchant vessel operators rate the performance of their current shipboard receiver(s) as being satisfactory. As Table 5-14 indicates, nearly three-fourths (72%) of the respondents acknowledge that the accuracy provided by their current receivers meets their navigation requirements; over a quarter (28%) of respondents contend otherwise.

TABLE 5-14

CURRENT RECEIVER(S) ACCURACY RATING

RESPONSE	PERCENT	CUMULATIVE PERCENT
Meets accuracy requirements	72	72
Does not meet requirements	28	100
		(162)

5.4.4 NEW RECEIVER PURCHASE PLAN

To determine the near term receiver purchase plans of the merchant vessel operators, the survey asked the respondents to specify the new radionavigation receiver they intended to purchase within the next two years.

5.4.4.1 Receiver Purchase Plan: Over half (53%) of merchant vessel respondents reported that they had no plans to purchase any receiver within the next 2 years (see Figure 5-9). Among 47% who planned to buy, 12% preferred hybrid receivers, 8% Transit receivers, 7% GPS receivers, another 7% a combination of Transit and LORAN-C receivers, 4% LORAN-C receivers only, 2% a combination of Transit, LORAN-C and GPS receivers, another 2% a combination of hybrid and GPS receivers, and the remaining 5% preferred some other combination of receivers.

5.4.5 REPLACEMENT UNIT PRICING PREFERENCES

The survey solicited information from the respondents on their price preferences for more accurate replacement receivers in two given situations: (1) when the current unit(s) did not meet the respondent's accuracy requirements, and (2) when the replacement units were intended for use with the proposed, more accurate radionavigation systems.

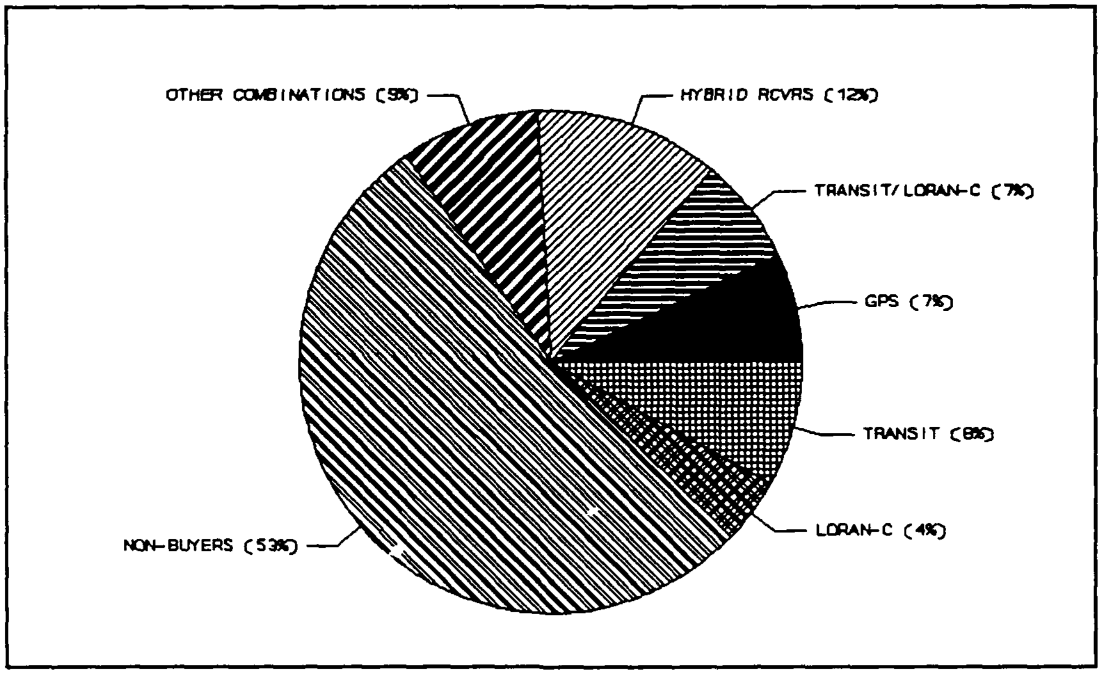

FIGURE 5-9. Receiver Purchase Plans in the Next Two Years

5.4.5.1 Prices for More Accurate Replacement Receivers: Half of the merchant vessel operators are willing to pay $4,000, and even higher amounts, to obtain greater position accuracy than currently possible (see Table 5-15). The median prices computed from the pricing data are: $4,000 for a more accurate replacement unit (reflecting the price preferences of those respondents who disclaimed their current receivers met their navigation accuracy requirements), $7,234 for the GPS receiver, $7,396 for the differential GPS receiver, $5,032 for the GEOSTAR receiver, $4,714 for the STARFIX receiver and also for the STARFIND receiver.

TABLE 5-15

HIGHEST PRICE FOR MORE ACCURATE REPLACEMENT RECEIVERS

RECEIVER TYPE	$2000 & <	$2001-4000	$4001-6000	$6001+	TOTAL
Replacement Unit	19%	31%	15%	35%	100% (30)
GPS	15	10	23	52	100 (72)
Differential GPS	13	8	18	61	100 (29)
GEOSTAR	19	15	31	35	100 (53)
STARFIX	26	19	14	41	100 (35)
STARFIND	34	11	14	41	100 (33)

5.5 MERCHANT VESSEL ATTRIBUTES: SELECTED CHARACTERISTICS

The survey posed two general questions to the respondents on the sources used for obtaining status information on navigation aids and on the shipboard electronic fixtures.

5.5.1 STATUS INFORMATION SOURCES

The respondents were asked to specify the methods they employed to get status information on navigation aids such as radiobeacons, LORAN-C, buoys, fog signals, etc.

5.5.1.1 Status Information Sources: The overwhelming choice of sources of status information for merchant vessel operators are printed weekly and local Notices to Mariners and marine radio broadcasts (see Figure 5-10). The following percentages show overlapping sources of status information: 69% of merchant vessels use printed local Notices to Mariners, 91% printed weekly Notices

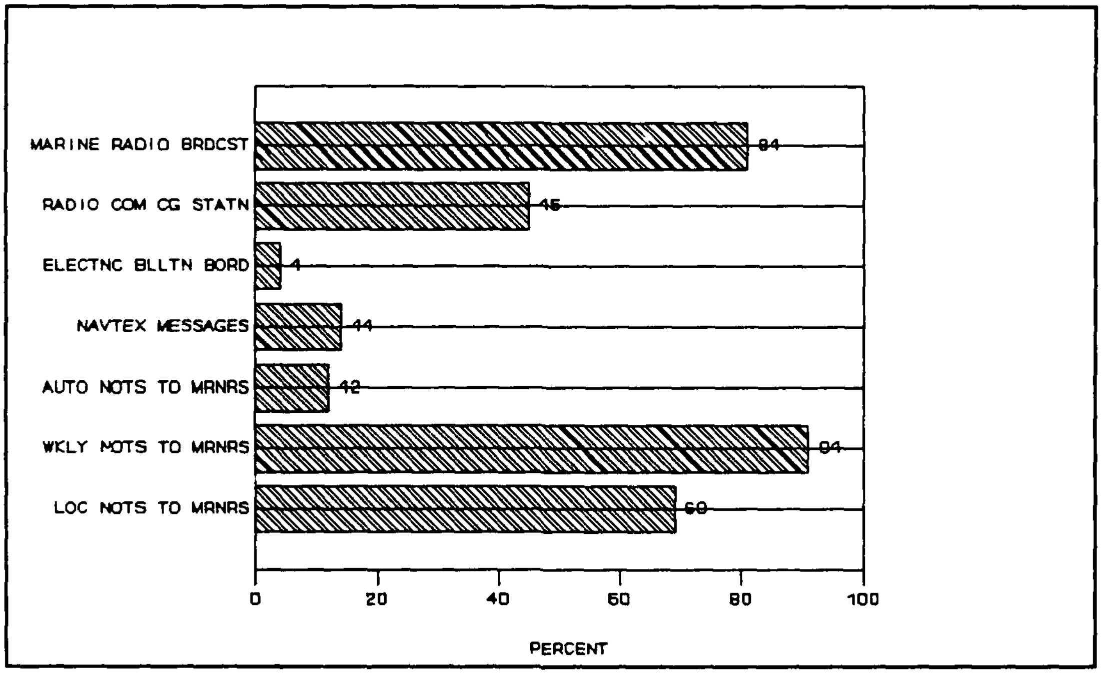

FIGURE 5-10. Sources Used to Receive RNS Status

to Mariners, 12% Automated Notices to Mariners, 14% NAVTEX messages, 4% electronic bulletin board services, 45% radio communication with local CG stations and 81% marine radio broadcasts. Other sources used are printed matter (2%), AMVER stations (1%) and charts (5%).

5.5.2 <u>ELECTRONIC FIXTURES ON BOARD</u>

The respondents were asked to specify the electronic equipment (other than radionavigation receivers) used on board such as depth sounder/sonar, radar, communications equipment, etc.

5.5.2.1 <u>Electronic Fixtures</u>: As Figure 5-11 shows, the most widespread electronic fixtures installed on merchant vessels are: radar (99% of vessels), communications equipment including portable

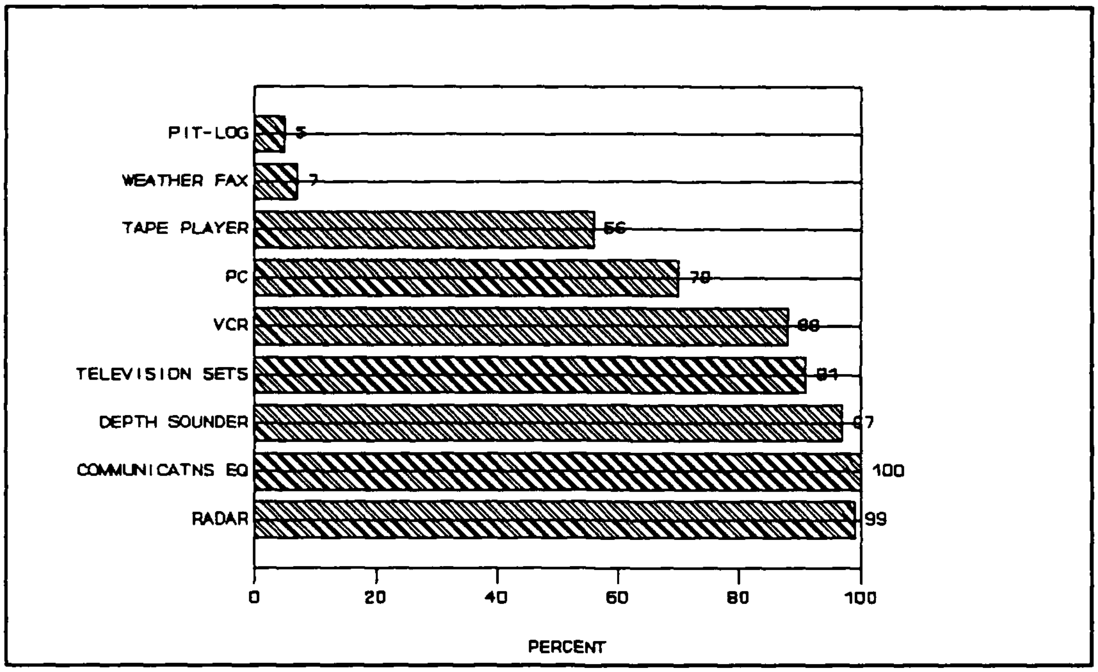

FIGURE 5-11. Electronic Fixtures on Board

transceivers (100%), depth sounder (97%), television set (91%), video cassette recorder (88%), personal computer (70%) and audio tape player (56%). Less widespread are: weather fax (7%), pit-log (5%) and EPIRB (2%). As for specific communications equipment, 97% of vessels carry VHF-FM receivers and transmitters and 1% ` ceivers only, 83% are equipped with HF-SSB receivers and transmitters and 1% with receivers only, 2% carry portable transceivers, 62% carry satellite communications receivers and transmitters, and 4% receivers only. Other communications equipment consisting of receivers and transmitters are found with much less frequencies: only 8% of vessels have CW/morse code equipment, 7% SITOR/telex equipment and 5% have cordless phones.

5.6 MERCHANT VESSEL RESPONDENT COMMENTS

At the end of the questionnaire, the respondents were invited

to make any comments or provide any additional information on the RNSs, USCG, the survey, etc.

5.6.1 Respondent General Comments: About 90% of merchant vessel respondents did not offer any comments. The following comments were made by 10% of respondents: 3% liked GPS, 3% asked LORAN-C be kept, 1% liked GPS but complained of inadequate status information, another 1% liked GPS and asked LORAN-C be kept, 1% requested more information on future RNS, 1% liked GPS and asked LORAN-C be kept but complained about inadequate status information, 1% praised USCG and 1% complained about inadequate RNSs.

5.7 SOME CONCLUDING REMARKS

Unlike the small craft owners, the merchant vessel operators expressed higher accuracy requirements in different waters and hoped to benefit from the increased accuracy of GPS. Their highly favorable attitudes towards GPS and other satellite-based services have largely been shaped by their experience with the Transit system which has proven to be highly satisfactory in terms of coverage and problem-free navigation. By relying primarily on Transit in the open oceans where most of the shipping occurs, the merchant vessel operators have, in essence, passed over the current non-satellite systems. The only exception is shipping in the coastal waters where, because of the inability of the Transit system to provide a continuous fix, LORAN-C is used extensively with or without the Transit system.

Among the salient findings discussed above, some are especially noteworthy:

A. Transit is the system most used by over three-quarters of merchant vessels in the open oceans and nearly two-thirds in the coastal waters.

B. Over three-quarters of merchant vessel operators find coverage for Transit and LORAN-C to be adequate and only half acknowledge adequate coverage for Radiobeacons.

C. The merchant vessel operators profess higher accuracy requirements in inland waters and the Great Lakes, somewhat lesser accuracy in coastal waters, and least of all in open oceans.

D. Nearly all (89-96%) respondents acknowledged the benefits of using RNSs, from improving navigation safety, to savings in fuel, time and indirect costs. On average, merchant vessels attributed annual savings of 19,326 gallons and 53 hours to Transit, and 14,207 gallons and 50 hours to LORAN-C.

E. Nearly three-fourths of the respondents are satisfied with the accuracy of current receivers. Over one-third (39%) will be unlikely users of differential LORAN-C service, and over half (51%) will be unlikely users of differential GPS.

F. Over two-thirds have knowledge of, or experience with GPS. Over four-fifths of the merchant vessel operators believe they will benefit from increased accuracy of 100 meters provided by the GPS.

G. A majority (63-80%) are not familiar with private satellite-based systems, but maintain they will benefit from their increased accuracies. Median prices for more accurate receivers range from $4,714 for STARFIX and STARFIND systems to $7,234 for GPS.

H. For the current systems, up to half the merchant vessel operators recommend a maximum transition period of four years. The one exception is Omega: over two-thirds of the operators indicated that it could be discontinued immediately.

I. For status information, 91% of merchant vessels rely on printed weekly Notices to Mariners and 69% rely on printed local Notices to Mariners.

6. TERRESTRIAL USERS

The questionnaire for the terrestrial users of radionavigation systems (RNSs) was designed to gather data on: terrestrial operators' appraisal of current RNSs, their predisposition towards the proposed more accurate systems and their requirements for system accuracies. From these findings, mean characteristics and RNS user population projections were computed. They are presented first.

6.1 MEAN CHARACTERISTICS AND RNS USER POPULATION PROJECTIONS

The mean characteristics and RNS user population projections are delineated in sections 6.1.1 and 6.1.2, respectively.

6.1.1 MEAN CHARACTERISTICS

The mean values of selected survey data show typical terrestrial RNS user characteristics, including usage pattern, terrestrial user preferences for receiver price, transition periods for non-satellite-based RNSs to GPSs, and requirements for radionavigation and location accuracy. Wherever the sample returns for a characteristic were too small to have any analytical value, the statistic in question was excluded from the listing of mean statistics below. All standard errors are computed to the 95% level of confidence. Note that some standard errors are quite large relative to the mean statistics because of extreme values and the small sample base for the variable in question.

Mean RNS Usage in Total Field Operations:

Transit	22% ± 11%
LORAN-C	19% ± 12%
GPS	35% ± 10%

Mean Lead Time Needed for Notice Advisories:

173 hours ± 90

Mean Notification Requirements of RNS Degradation:

Short Delay 39 minutes ± 38

Mean Fuel and Time Savings Due to RNS:

Fuel Savings Due to GPS	285 gallons	± 247
Time Savings Due to GPS	808 hours	± 500

Mean Horizontal Accuracy Requirements:

Mapping & Geodetic Control	1.0 meters	± 0.8
Vehicle Position Monitoring	7.8 meters	± 4.2

Mean RNS Transition (in years):

Radiobeacons	6 yrs	± 3
Omega	2 yrs	± 0.4
Transit	4 yrs	± 1
LORAN-C	7 yrs	± 3

Preferred Highest Mean Purchase Price for Receivers:

More Accurate Replacement Unit	$88,194	± $25,929
GPS Unit	37,321	± 14,783
Differential GPS Unit	47,921	± 16,495

6.1.2 RNS USER POPULATION PROJECTIONS

There are an estimated 865 terrestrial users of RNSs out of the survey universe of 1,183 terrestrial surveyors and mappers. The standard error for the estimate is ± 96 users. These users employ one or more RNSs in their operations. The estimates of users for each RNS are given below. The corresponding receiver population projections have not been made because many, if not most, terrestrial users of RNSs do not own the receivers but lease them. Accordingly, any receiver projections based on ownership data would provide low population estimates that would be quite misleading.

Each estimate of users of a RNS is independent of others because of the overlap of users from system to system; hence, the sum of user populations below exceeds the total of 865 terrestrial users of RNSs. Note that some standard errors are quite large relative to the statistics because of small sample bases.

Transit	203 ± 81	users
LORAN-C	303 ± 94	users
GPS	716 ± 105	users
Trisponder	81 ± 62	users
ARGO	50 ± 43	users

The distribution of system users in percentages is as follows: the Transit system is used by 23% of terrestrial users of RNSs, LORAN-C by 35%, GPS by 83%, Trisponder by 9% and ARGO by 6%.

The terrestrial users of the Radiobeacons, Omega and Syledis systems have not been estimated because a very small number of users responded in the sample returns.

6.2. CURRENT RADIONAVIGATION SYSTEMS: SYSTEM USAGE, COVERAGE, BENEFITS, AND PHASE-OUT PERIOD

The survey asked the terrestrial users of RNSs to indicate the systems employed and the rate of usage in their operations, and to evaluate system coverage and accuracy. The users were also asked to rate the benefits, specify the problems encountered and indicate the preferred phase-out period of current systems in favor of GPS. The salient findings are given below.

6.2.1 SYSTEMS AND USAGE

The terrestrial users of RNSs were asked to specify the type of receiver(s) used for land positioning/navigation and if more than one receiver type was used, the type used most. The information on receiver type would yield data on the systems and system users. They were also asked to specify the percent of the time the receivers were used in their total field operations. Such information would yield data on the rate of RNS usage. Finally,

the terrestrial users of RNSs were asked to specify the type of receiver(s) used in their operations to indicate what type of receiver was used in which operation.

6.2.1.1 System Users: Over a quarter (27%) of respondents reported they did not use any radionavigation receiver (see Table 6-1). Among 73% terrestrial users of RNSs, the single system users are more numerous than multi-system users. There are 44% single system users, of which 35% are GPS users, 6% LORAN-C, 2% Trisponder, and 1% Transit users. The 29% multi-system users employ a varied mix of systems in their operations. When asked to identify the primary system used in multi-system operations, about 13% reported using GPS as the primary system, 5% Transit, 3% LORAN-C, 2% Trisponder, 1% ARGO, another 1% Syledis and 4% other systems.

TABLE 6-1

RADIONAVIGATION SYSTEM USERS

SYSTEM USER GROUP	PERCENT	CUMULATIVE PERCENT
No system users	27	27
Single system users	44	71
Multi-system users	29	100
		(106)

6.2.1.2 Incidence of RNS Utilization: As Table 6-2 shows, the highest (mode) field use rate and the percent of users for each system are: 6-10% by 24% for Transit, 1-5% by 47% for LORAN-C and 1-5% by 32% for GPS. The median field use rates are 10%, 6% and 15% respectively. The Omega system data is not discussed here due to the small number of users in the sample returns.

TABLE 6-2

RADIONAVIGATION SYSTEM FIELD USAGE RATE

USE RATE	OMEGA	TRANSIT	LORAN-C	GPS
0%	0%	8%	0%	0%
1 - 5%	29	20	47	32
6 - 10	0	24	30	15
11 - 15	71	0	0	3
16 - 20	0	0	5	6
21 - 25	0	18	0	2
26 - 50	0	6	0	11
51 - 75	0	6	9	3
76 - 100	0	18	9	28
	100	100	100	100
	(4)	(14)	(18)	(57)

6.2.1.3 Operations in Which RNSs are Used: The highest use of RNSs in terrestrial operations is for mapping and geodetic control, followed by vehicle position monitoring, seismic surveys and exploration. Note that the following statistics show system users who may overlap among various operations and, therefore, each cell value should be viewed independently of others. As Table 6-3 shows, the Transit system is used by almost all terrestrial users (93%) in mapping and geodetic control operation, by 4% in vehicle position monitoring, 39% each in rig positioning and seismic surveys, 17% in cadastral, 39% in exploration and 7% each in dredging and pipe laying. The LORAN-C system is used by 37% terrestrial users of RNSs in mapping and geodetic control, 39% in vehicle position monitoring, 13% in rig positioning, 23% in seismic surveys, 4% in cadastral, 24% in exploration, and 19% in dredging. Similarly, the GPS is used by 79% in mapping and geodetic control, 12% in vehicle position monitoring, 9% in rig positioning, 19% in seismic surveys, 31% in cadastral, 16% in exploration, 11% in

dredging and 3% in pipe laying.

TABLE 6-3

RNS USERS BY OPERATIONS

OPERATIONS	USERS OF		
	TRANSIT	LORAN-C	GPS
Mapping and geodetic control	93%	37%	79%
Vehicle position monitoring	4	39	12
Rig positioning	39	13	9
Seismic surveys	39	23	19
Cadastral	17	4	31
Exploration	39	24	16
Dredging	7	19	11
Pipe Laying	7	0	3
	(16)	(21)	(60)

Note: Each cell value is independent of other cell values.

6.2.2 COVERAGE AND ACCURACY

The USCG is interested in the feedback from the survey respondents on their rating of the coverage and accuracy of RNSs and also on their accuracy requirements. Accordingly, the survey addressed several questions on these issues to the respondents.

6.2.2.1 RNS Coverage: The Transit system coverage was rated adequate by as many system users as LORAN-C system coverage was assessed inadequate (see Figure 6-1). Almost two-thirds (64%) of the Transit users reported the system coverage to be adequate; in contrast, only one-third (34%) of LORAN-C users found it to be so. The Omega system did not have a sufficient sample returns base for a meaningful analysis.

6.2.2.2 Satisfaction Rating of RNS Accuracy: In general, the respondents rated the accuracy of each RNS, except Omega which is

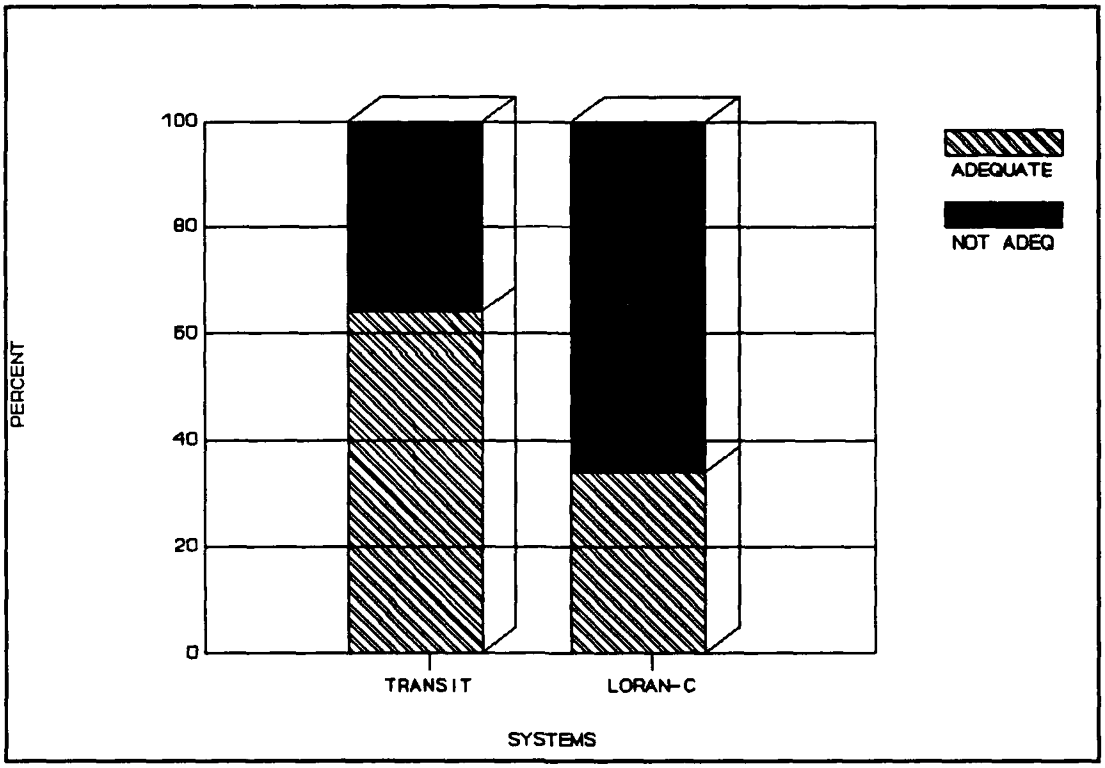

FIGURE 6-1. Systems Ratings for Adequacy of Signal Coverage

not analyzed here, as satisfactory. Nearly 90% of the Transit system users are satisfied with its accuracy, with 58% very satisfied and 32% somewhat satisfied (see Figure 6-2). All LORAN-C users, on the other hand, claim they are satisfied with its accuracy, with over one-third (37%) professing to be very satisfied and nearly two-thirds (63%) somewhat satisfied. Similarly, almost all GPS users (98%) are satisfied with the system accuracy, with over three-fourths (77%) very satisfied and 21% somewhat satisfied.

6.2.2.3 <u>Accuracy Requirements</u>: The survey asked respondents to specify their accuracy requirements for each of their operations. The number of respondents for most operations listed in the questionnaire were disappointingly low and insufficient for any meaningful analysis. For two operations, however, the response

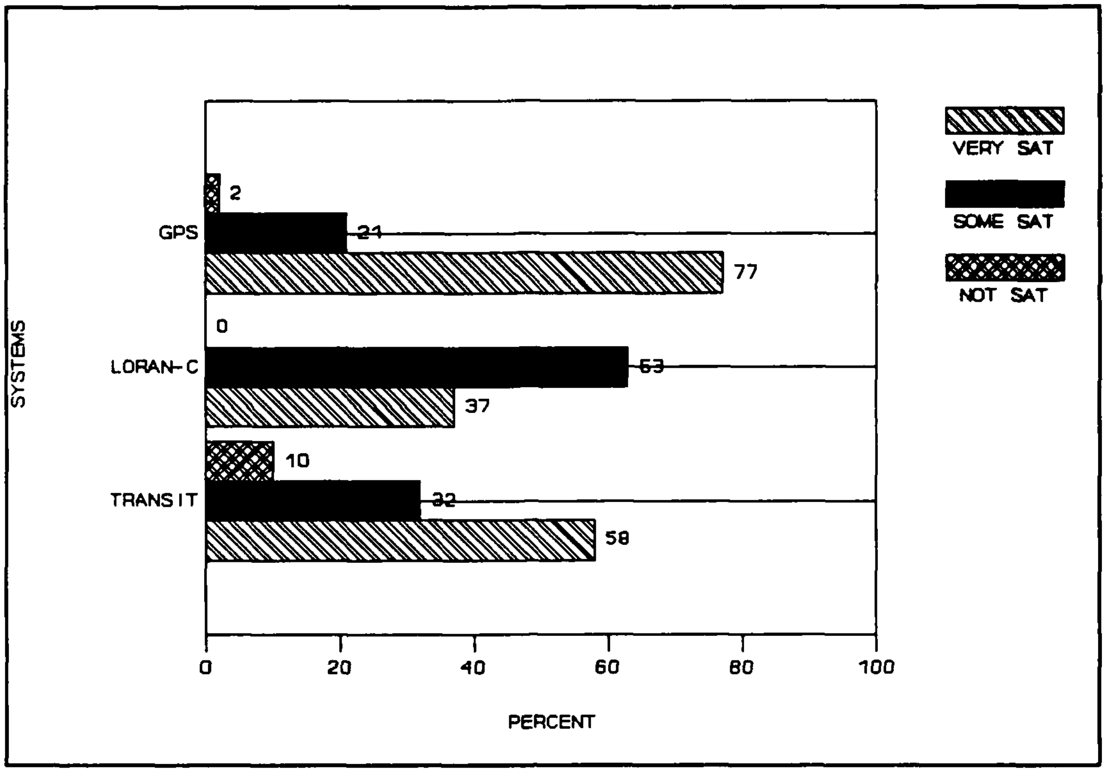

FIGURE 6-2. Satisfaction Rating of RNS Accuracy

was large enough to permit the following analysis of survey data. As Table 6-4 indicates, the modal horizontal accuracy requirement for mapping and geodetic control is one meter or less for 86% of respondents, and for vehicle position monitoring operation 1.1-5.0 meters for 34% of respondents. The median accuracy requirement for the latter operation is 4.2 meters.

TABLE 6-4

TERRESTRIAL OPERATIONS ACCURACY REQUIREMENTS

ACCURACY LEVEL	MAPPING & GEODETIC CONTROL	VEHICLE MONITOR POSITIONING
1 meter or less	86%	28%
1.1 - 5.0 m	8	34
5.1 - 10.0 m	4	18
10.1 - 15.0 m	0	0
15.1 - 20.0 m	2	8
20.1 m and above	0	12
	100	100
	(42)	(20)

6.2.3 BENEFITS AND PROBLEMS

The benefits of using RNSs were listed in the questionnaire as savings in time, fuel and indirect costs. The appraisal of the importance of benefits and the value put on these benefits by the terrestrial users of RNSs would provide important information to the USCG. Similarly, the problems generally encountered by users of RNSs were listed in the questionnaire as no signal available, weak signal, interference, and inaccurate readings. Identifying the type and extent of problems encountered by the terrestrial users while using the RNSs would also provide useful feedback to the USCG.

6.2.3.1 RNS Benefits Rating: Fuel savings are rated by fewer terrestrial operators as a benefit from using the RNSs than time and indirect cost savings. Whereas only two-thirds (66%) credit fuel savings to the use of RNS, nearly all (97-98%) attribute indirect cost savings and time savings to the use of RNSs (see Figure 6-3).

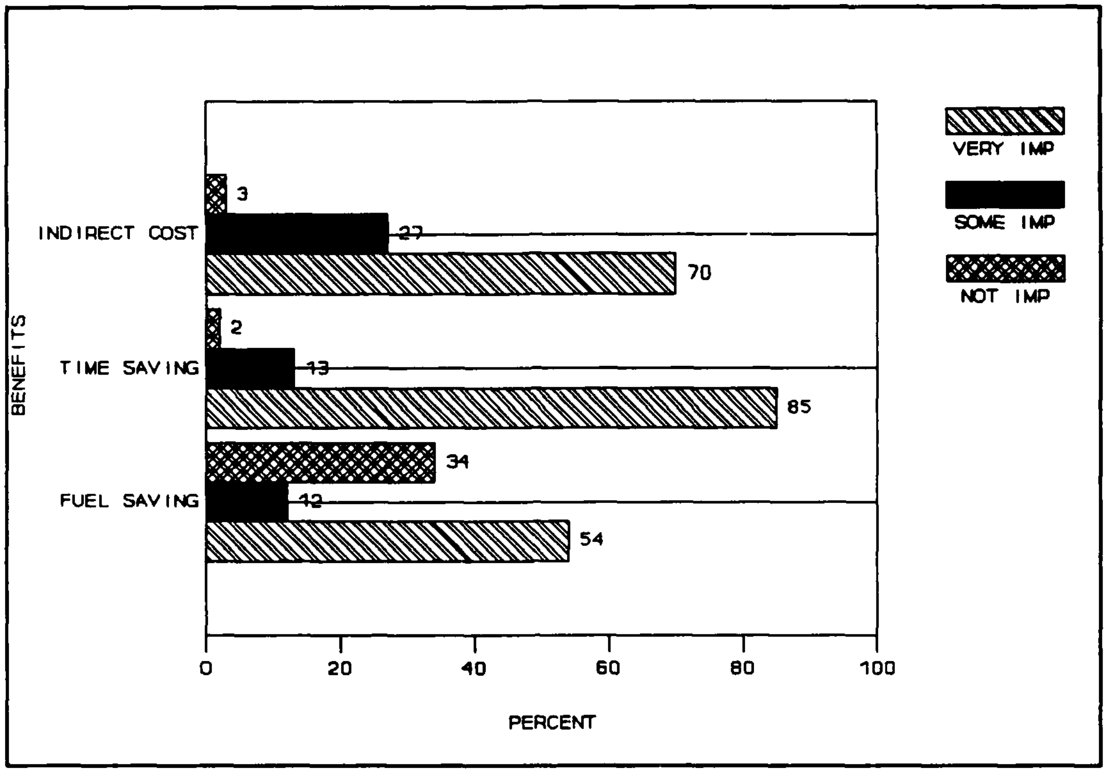

FIGURE 6-3. Rating the Importance of RNS Benefits

6.2.3.2 Savings Attributed to RNS: Most terrestrial users of Omega, Transit and LORAN-C did not specify actual savings attributed to the use of those RNSs. Because the number of respondents was very small in each case, their answers could not be meaningfully analyzed. In the case of GPS users, however, only about one-third (35%) claimed varying amounts of annual fuel savings (see Table 6-5): over 500 gallons by 15%, 401-500 gallons by 7%, 301-400 gallons by 6% and 1-100 gallons by 7% of GPS users. In contrast, 82% of GPS users attributed time savings to GPS: 42% claimed annual savings between 1-500 hours, 12% between 501-1,000 hours, 5% between 1,001-1,500 hours, 6% between 1,501-2,000 hours, 5% between 2,001-2,500 and 12% claiming 5,000 hours. The median time savings is 300 hours.

TABLE 6-5

ANNUAL SAVINGS DUE TO GPS

Fuel Savings (gallons)	PERCENT	CUMULATIVE PERCENT
0	65	65
1 - 100	7	72
101 - 200	0	72
201 - 300	0	72
301 - 400	6	78
401 - 500	7	85
501 and above	15	100
		(15)
Time Savings (hours)		
0	18	18
1 - 100	15	33
101 - 200	12	45
201 - 300	5	50
301 - 400	0	50
401 - 500	10	60
501 and above	40	100
		(18)

6.2.3.3 RNS Problems: Asked to specify the extent of signal problems encountered, most users of RNSs chose not to respond. Consequently, the number of respondents for each system were not large enough for a meaningful analysis of the data.

6.2.4 PHASE-OUT PERIOD

The respondents were asked to specify the phase-out period for the current RNSs after GPS became fully operational.

6.2.4.1 Transition Periods from Current RNSs to GPS: When asked to state their preferences for the transition periods from

current RNSs to GPS, most terrestrial users of RNSs chose not to answer, thus showing a lack of interest in the question. Among the respondents, as Table 6-6 shows, the modal years of choice for each RNS were 1-5 years for all RNSs by about half the respondents. The median years were: 3 for Radiobeacons, 0.5 for Omega, 3 for Transit, and 4 for LORAN-C. Note that the transition period for all RNSs was capped at 50 year maximum.

TABLE 6-6

PHASE-OUT PERIOD FOR CURRENT RADIONAVIGATION SYSTEMS

YEARS	RADIOBEACONS	OMEGA	TRANSIT	LORAN-C
0	19%	45%	18%	11%
1 - 5	47	55	58	49
6 - 10	22	0	24	36
11 and above	12	0	0	4
	100	100	100	100
	(21)	(15)	(31)	(38)

6.3 PROPOSED RADIONAVIGATION SYSTEMS: AN ASSESSMENT OF TERRESTRIAL USERS' PREDISPOSITION TOWARDS MORE ACCURATE SYSTEMS

To probe the predisposition of the terrestrial users of current RNSs towards the more accurate systems, a series of questions on the proposed systems were addressed in the questionnaire. The salient findings are discussed below.

6.3.1 DIFFERENTIAL LORAN-C

The respondents were asked if differential LORAN-C service was provided free by the government and an accuracy of less than 20 meters could be obtained within a 50-mile radius of the reference stations, would they purchase a differential receiver, modify an existing LORAN-C receiver, or be unlikely users of the service?

6.3.1.1 Reaction to Differential LORAN-C Service: Two-thirds (66%) of the respondents stated that they would be unlikely users of differential LORAN-C service even when freely provided by the government (see Figure 6-4). Among the one-third who would use the service, 18% said they would buy a differential receiver and 16% would modify an existing LORAN-C receiver.

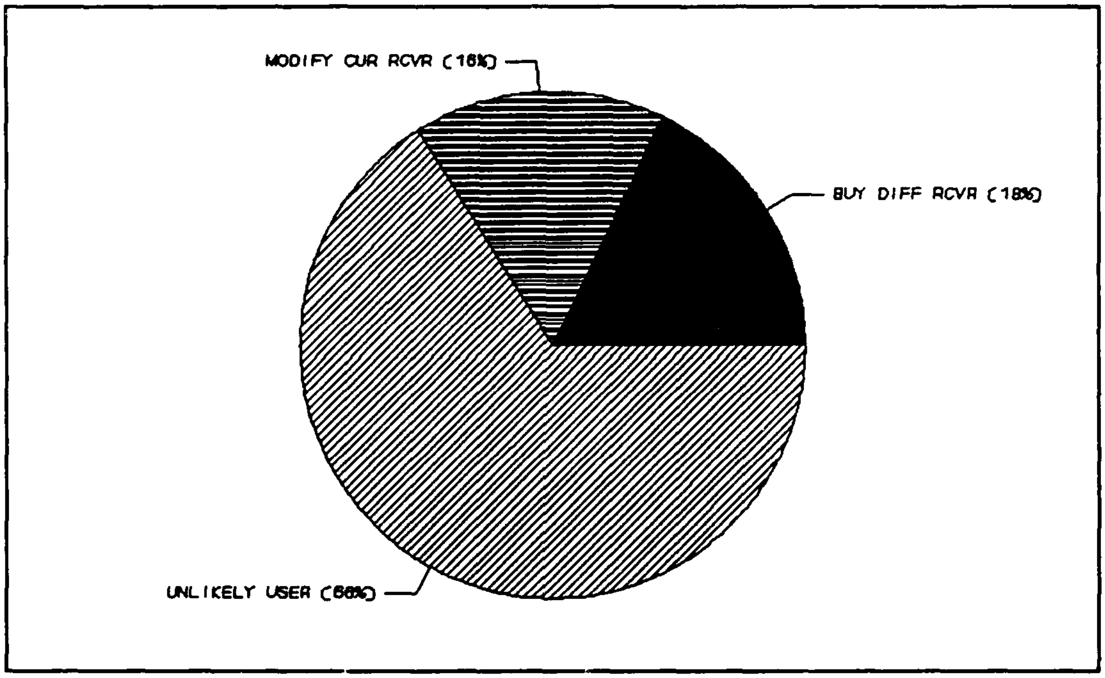

FIGURE 6-4. Reaction to Differential LORAN-C Free Service

6.3.2 GLOBAL POSITIONING SYSTEM

On the GPS, two questions were directed at the respondents to determine their level of awareness of the system and whether the planned accuracy of 100 meters would benefit them.

6.3.2.1 Familiarity with GPS: As a group, the terrestrial users of RNSs are generally quite knowledgeable about GPS. Over 70% indicated they had some operational experience with GPS, and 24% said they had no experience but were informed about GPS through

exposure to professional or other literature (see Figure 6-5). Only 6% acknowledged they had neither knowledge of nor experience with GPS.

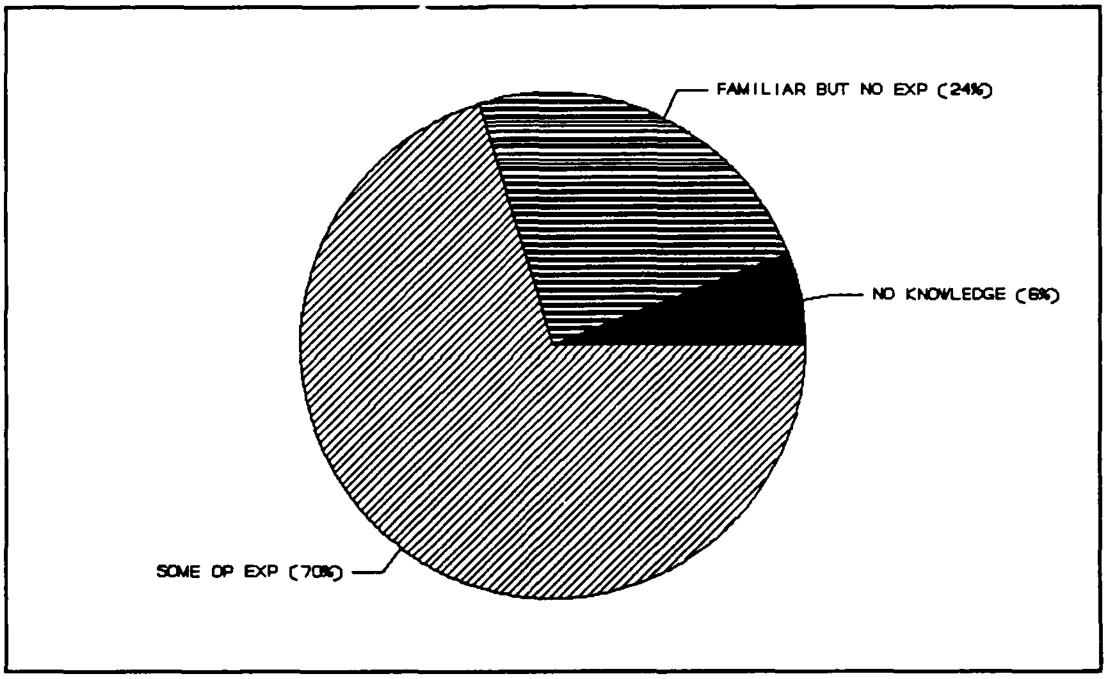

FIGURE 6-5. Familiarity with GPS

6.3.2.2 Benefit From Increased GPS Accuracy: As Table 6-7 indicates, almost three-quarters (72%) of respondents stated that they would not benefit from the increased positional accuracy of 100 meters provided by GPS; only 28% affirmed they would.

TABLE 6-7

GPS ACCURACY* VIEWED AS POTENTIAL BENEFIT

RESPONSE	PERCENT	CUMULATIVE PERCENT
Will benefit from GPS accuracy	28	28
Will not benefit	72	100
		(93)

*100 meters or better horizontally

6.3.3 DIFFERENTIAL GLOBAL POSITIONING SYSTEM

The respondents were asked if the differential GPS service was provided by the government at no cost and had an accuracy of less than 20 meters within a 100-mile radius, would they purchase a differential GPS receiver, modify an existing receiver, or be unlikely to use the service?

6.3.3.1 Reaction to Differential GPS: As Figure 6-6 shows, the reaction to the availability of differential GPS was mixed: 61% of respondents indicated an interest, and 39% stated they would be unlikely users. Among the former, 45% said they would buy differential GPS receivers and 16% preferred modifying the installed receivers.

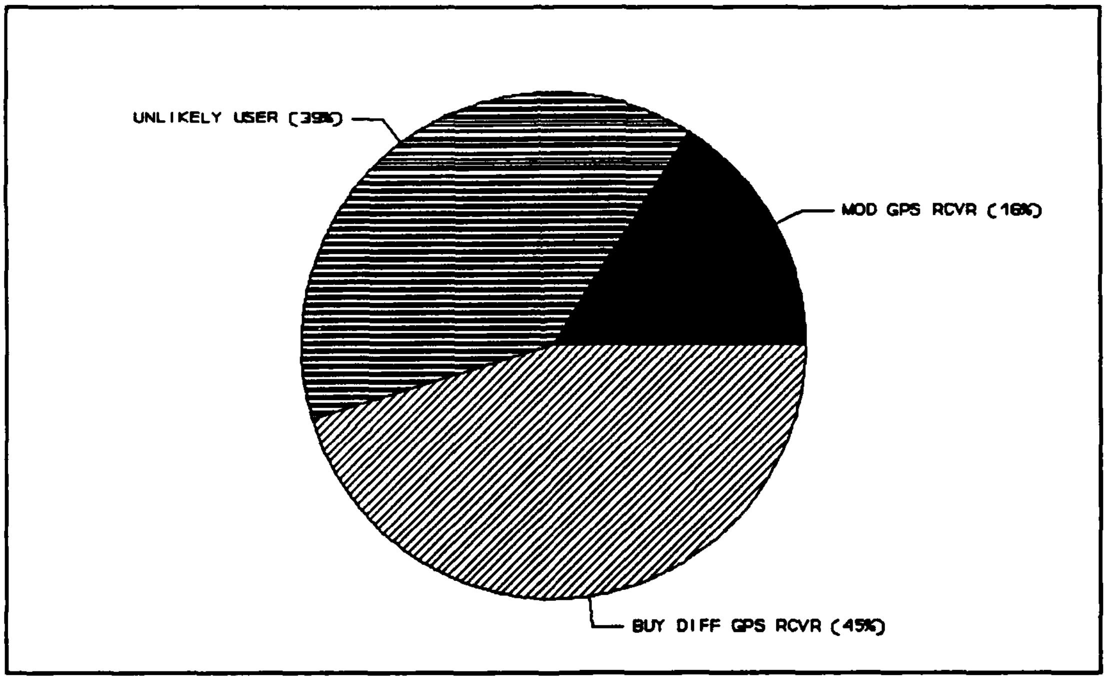

FIGURE 6-6. Reaction to Differential GPS Free Service

6.3.4 PRECISE POSITIONING SERVICE

The respondents were told that the PPS, with an accuracy of 20 meters or less, might be available to the general public provided a need was demonstrated, users had exhausted alternative sources and its use was in the national interest. They were asked if access to PPS was needed.

6.3.4.1 Access to PPS: The interest in the more accurate PPS was high among terrestrial operators. As Table 6-8 indicates, over half (55%) of respondents stated they needed access to the service, and a quarter (25%) said they were not sure. Only 20% showed no interest.

TABLE 6-8

NEED FOR ACCESS TO PPS

RESPONSE	PERCENT	CUMULATIVE PERCENT
PPS access not required	20	20
Not sure	25	45
PPS access required	55	100
		(97)

6.3.5 PRIVATE SATELLITE SYSTEMS

On several privately developed and maintained satellite-based systems, the questionnaire asked the respondents to indicate their familiarity with and need for the planned accuracies of the systems.

6.3.5.1 Familiarity with Private Satellite-based Systems: As Table 6-9 indicates, a majority of respondents were unfamiliar with private satellite-based radionavigation services: over half (53%) of respondents were unfamiliar with GEOSTAR, over two-thirds (68%) with STARFIX and over four-fifths (84%) with STARFIND. Among those somewhat familiar with the services, the largest number (38%) were

familiar with GEOSTAR, followed by 27% with STARFIX and 15% with STARFIND. As for those very familiar, 9% were with GEOSTAR, 5% with STARFIX and 1% with STARFIND.

TABLE 6-9

FAMILIARITY WITH PRIVATE SATELLITE-BASED SYSTEMS

FAMILIARITY LEVEL	GEOSTAR	STARFIX	STARFIND
Not Familiar	53%	68%	84%
Somewhat Familiar	38	27	15
Very Familiar	9	5	1
	100	100	100
	(93)	(92)	(91)

6.3.5.2 Need for Planned Accuracies of Private Satellite-based Systems: As Table 6-10 indicates, a majority of terrestrial users of RNSs showed no interest in the planned accuracies of private satellite-based services: 91% of respondents said their requirements would not be met with GEOSTAR accuracy of 100 meters, 73% with STARFIX accuracy of 10 meters and 66% with STARFIND accuracy of 6 meters.

TABLE 6-10

TERRESTRIAL OPERATORS SIGNIFYING NEED FOR ACCURACY OF PRIVATE SATELLITE-BASED SYSTEMS

NEED FOR ACCURACY	GEOSTAR (100 m)	STARFIX (10 m)	STARFIND (6 m)
Yes	9%	27%	34%
No	91	73	66
	100	100	100
	(70)	(69)	(68)

6.4 RECEIVING SYSTEMS: CURRENT UNIT(S) AND REPLACEMENT PRICING AND PLANS

In the terrestrial survey, a few questions on the receiving systems were included to obtain information from the respondents on: receiver performance, receiver applications, new receiver purchase plans and replacement unit pricing preferences. No question on the number of receivers owned by the terrestrial users of RNSs was included because most terrestrial users do not own the receivers; instead they lease them for periods of time as needed. The salient findings on the receiving systems are reported below.

6.4.1 RECEIVER APPLICATIONS

The receiver applications are generally for obtaining position, direction, range, time, etc. For information on receiver applications in land navigation by the terrestrial operators, the respondents were asked to indicate their receiver applications, including the primary use.

6.4.1.1 Receiver Information Applications: As Table 6-11 shows, among terrestrial operators using the Transit system, 49% use receivers solely for obtaining position from receiver display, and 34% solely for precise processed positioning. The remaining 17% report multiple applications: 7% combine the two applications, 4% mix obtaining the position with PTTI, and 6% combine precise processed positioning with PTTI. In the case of terrestrial users of LORAN-C, about 97% report single application to obtain position and 3% report multiple applications that combine position with PTTI. Among the former, 60% employ normal mode, 20% repeatable mode, and 17% rho-rho mode. The GPS users, on the other hand, report a variety of applications of information obtained from receivers. Among 59% of GPS users reporting single receiver application, 28% apply receivers for obtaining precise processed positioning, 24% for obtaining position, 5% for PTTI and 2% for velocity determination. As for 41% of GPS users reporting multiple

TABLE 6-11

RECEIVER APPLICATIONS IN LAND NAVIGATION

INFORMATION	OMEGA	TRANSIT	LORAN-C	GPS
Position only	100%	49%	97%	24%
Precise processed positioning only	0	34	0	28
PTTI only	0	0	0	5
Velocity only	0	0	0	2
Various combinations	0	17	3	41
	100	100	100	100
	(4)	(16)	(21)	(60)

receiver applications, 11% use receivers to obtain position and stored waypoints, 7% position and PTTI, another 6% position and precise processed positioning, 5% position/PTTI/precise processed positioning, 2% position and elevation, and 10% report all other combinations of applications. The primary application by the 41% GPS users reporting multiple receiver applications is as follows: 20% use receivers primarily to obtain position, 14% stored waypoints and velocity, 5% PTTI and 2% stored waypoints only.

6.4.2 RECEIVER PERFORMANCE

The survey asked the respondents to evaluate the receivers on the accuracy obtained in the field operations.

6.4.2.1 Receiver Accuracy Evaluation: Although a majority (60%) of respondents stated that the receivers they used in the field operations met their accuracy requirement, a sizable minority (40%) answered negatively (see Table 6-12). The problem that the latter seem to be highlighting is not so much the receiver technology which is quite advanced at the top end of the line of receivers; rather the problem is the system accuracy itself which

is deficient in providing the desired accuracy.

TABLE 6-12

CURRENT RECEIVER(S) ACCURACY RATING

RESPONSE	PERCENT	CUMULATIVE PERCENT
Meets accuracy requirements	60	60
Does not meet requirements	40	100
		(62)

6.4.3 NEW RECEIVER PURCHASE PLAN

To determine receiver purchase plans of the terrestrial operators within the next two years, the respondents were asked to identify the type of receiver they had considered buying.

6.4.3.1 Receiver Purchase Plans: As many as 40% of respondents stated they did not intend to buy any receiver within the next two years (see Figure 6-7). In contrast, 50% of respondents declared they would purchase GPS receivers, 3% a combination of LORAN-C and GPS, 2% hybrid receivers, 1% each Transit and GPS/hybrid receiver, and 3% other combinations (like Omega/Transit/LORAN-C, GPS/other receivers, and so on).

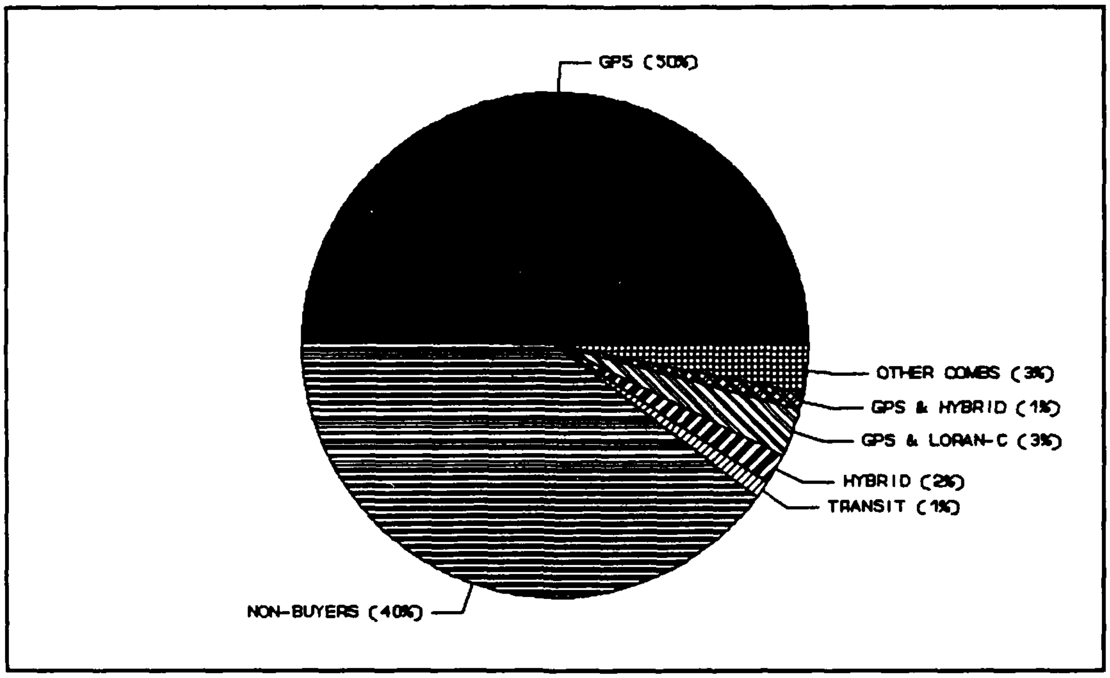

FIGURE 6-7. Receiver Purchase Plans in the Next Two Years

6.4.4 REPLACEMENT UNIT PRICING PREFERENCES

For information on the receiver price preferences of terrestrial operators, the respondents were asked to state the highest price they would be willing to pay for a replacement receiver unit corresponding to the proposed, more accurate radionavigation systems included in the survey.

6.4.4.1 Prices for Optional Receivers: The terrestrial users of RNSs who are dissatisfied with the accuracy obtained by their current receivers show a willingness to pay substantial amounts for a more accurate replacement unit. As Table 6-13 indicates, the modal price range for a replacement unit is $50,001-100,000 for 39% of respondents and the median price is $65,385. On the other hand, when all terrestrial operators, including those satisfied with the accuracy obtained by the current receivers, were asked about their price preferences, the prices stated were much lower. For the GPS receiver, the modal price range is $5,000 and below for 36% of

respondents and the median price is $19,167. On the other hand, the modal price range for the differential GPS receiver is $50,001 and above for 23% of respondents and the median price is $29,412. The preferred prices for private satellite-based service receivers are not reported here because of small sample returns.

TABLE 6-13

HIGHEST PRICE FOR MORE ACCURATE REPLACEMENT RECEIVERS

PRICE RANGE	PERCENT	CUMULATIVE PERCENT
	Replacement Unit	
$10,000 and below	9	9
$10,001 - 50,000	29	38
$50,001 - 100,000	39	77
$100,001 and above	23	100
		(21)
	GPS	
$ 5,000 and below	36	36
$ 5,001 - 10,000	3	39
$10,001 - 20,000	12	51
$20,001 - 30,000	19	70
$30,001 - 40,000	0	70
$40,001 - 50,000	6	76
$50,001 and above	24	100
		(20)
	Differential GPS	
$ 5,000 and below	16	16
$ 5,001 - 10,000	12	28
$10,001 - 20,000	6	34
$20,001 - 30,000	17	51
$30,001 - 40,000	9	60
$40,001 - 50,000	17	77
$50,001 and above	23	100
		(32)

6.5 TERRESTRIAL USER ATTRIBUTES: SELECTED CHARACTERISTICS

The survey addressed a series of questions to the terrestrial users of RNSs on: base of operation, area of operation, sources used for status information, lead time required for notice advisories and lead time required for notice of RNS degradation. The salient findings are discussed below.

6.5.1 BASE OF OPERATIONS

With the scope of the survey limited to terrestrial users of RNSs operating on the land mass (including land-locked lakes) and offshore waters, respondents were asked to specify their base of operation so as to confine the study to those operators only.

6.5.1.1 Incidence of Surface Operators: As Table 6-14 indicates, most (91%) respondents identified surface and offshore areas as their base of operations: 73% operate on the land mass and 18% offshore. A small minority, 9% of respondents, reported the open oceans (7%) and rivers or other areas (2%) as their bases of operations.

TABLE 6-14

BASE OF TERRESTRIAL OPERATIONS

	PERCENT	CUMULATIVE PERCENT
Land mass and land-locked lakes	73	73
Offshore areas	18	91
Ocean waters	7	98
Rivers and other areas	2	100
		(74)

6.5.2 REGION OF OPERATIONS

For information on the area of operations, respondents were asked to specify the states in which they use the receivers regularly to get navigation/positioning information.

6.5.2.1 Region of Operations: A sizable number of terrestrial operators confine their operations to one geographical area. A majority, however, operate in more than one region. The regions within the United States as mentioned below follow the regional classification scheme for states used in the Statistical Abstract of the United States. As Table 6-15 shows, 47% of Transit system users confine their operations to one region only: 29% overseas, and 18% in the Pacific region. The remaining 53% use the Transit system in more than one region: 11% in all states, 12% in Middle Atlantic region and overseas, 8% on Gulf/East/West coasts, 6% in West South Central and Mountain regions, another 6% in the Caribbean and overseas, 5% in all states and overseas, and another 5% in West South Central region and Gulf coast. As for the LORAN-C system, only 36% terrestrial operators reported their operations were confined to one region only: 11% in the Pacific region, 9% overseas, 6% in East North Central region, 5% each in South Atlantic and another 5% in West South Central region. The remaining 64% use LORAN-C in more than one region: 6% in all states, 12% in South Atlantic/East South Central/West South Central regions, 10% on Gulf/East/West coasts, 9% in Middle Atlantic region and overseas, 6% each in Gulf/East coasts/Caribbean and Middle Atlantic/South Atlantic regions, and 5% each in Gulf coast/Caribbean, Gulf/East coasts and all states/overseas. The GPS is used by 47% terrestrial operators in one region only: 11% in Pacific region, 8% each in South Atlantic region and Mountain region, 7% each overseas and in West South Central region, and 2% each in Mid Atlantic region, East North Central region and New England region. The remaining 53% use GPS in more than one region: 17% in all states, 6% in Mountain/Pacific regions, 3% each in West South Central/Mountain regions, Middle Atlantic/overseas, and South Atlantic/East South Central/West South Central regions, and 2% each in Gulf/East/West coasts, East North Central/West North Central regions, Gulf/East coasts, East North Central/East South Central/South Atlantic regions, and 13% in all other regional

combinations.

TABLE 6-15

SINGLE AND MULTI-REGION TERRESTRIAL OPERATORS

REGION	TRANSIT	LORAN-C	GPS
One region operation	47%	36%	47%
Multi-region operation	53	64	53
	100	100	100
	(14)	(18)	(54)

6.5.3 STATUS INFORMATION SOURCES

The respondents were asked to specify the methods employed by them to get status information on the RNSs.

6.5.3.1 Status Information Sources: Over a quarter (27%) of terrestrial users of RNSs do not receive status information from any source. The nearly three-quarters who reported receiving status information use varied sources. The following percentages show overlapping status information sources. The most widely used source is, as Figure 6-8 depicts, electronic bulletin boards by 37% terrestrial operators. Other less commonly used sources are: Air Force by 18% terrestrial operators, Navy by 9%, radio communications with local CG stations by 9%, marine radio broadcasts by 8%, NAVTEX messages by 7%, printed local Notices to Mariners by 13%, printed weekly Notices to Mariners by 5%, automated Notices to Mariners by 6%, system vendors by 2% and data tie line by 2%.

6.5.4 LEADTIME REQUIREMENT FOR NOTICES

The respondents were asked to specify their leadtime requirements for notice advisories and system degradation notice.

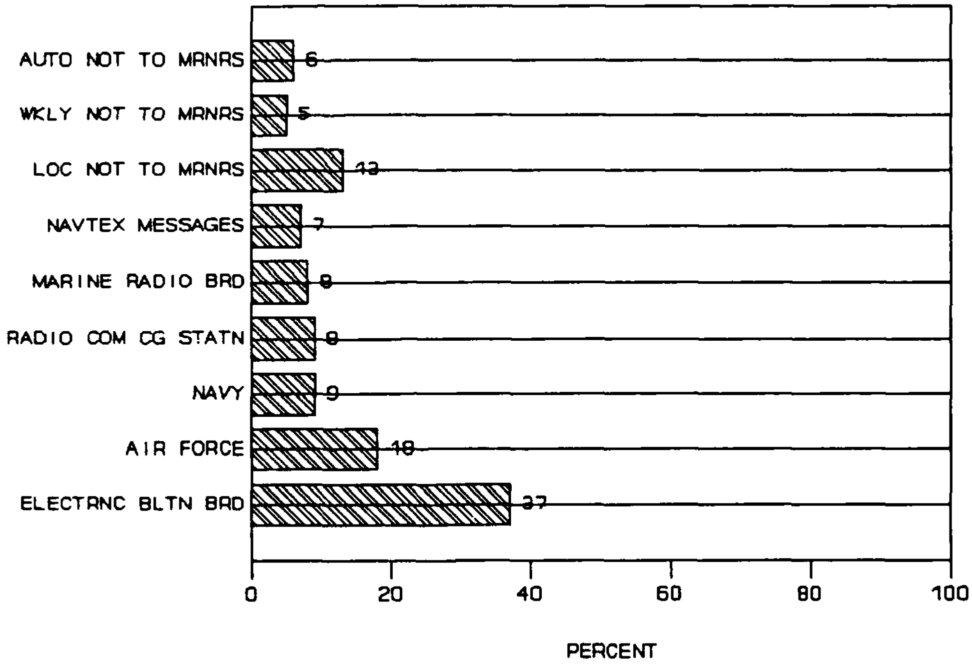

FIGURE 6-8. Sources Used to Receive RNS Status

6.5.4.1 Leadtime for Advisories: The modal category for leadtime requirement is 1-24 hours by 35% of respondents, and the median is 30 hours (see Table 6-16).

TABLE 6-16

LEADTIME REQUIREMENT FOR NOTICE ADVISORIES

LEADTIME	PERCENT	CUMULATIVE PERCENT
0 hours	12	12
1 - 24 hours	35	47
25 - 48	12	59
49 - 168	13	72
169 - 336	20	92
337 and above	8	100
		(50)

6.5.4.2 Leadtime for System Degradation Notice: The respondents were asked to define their leadtime requirements in near real time (within one minute), short delay (in minutes), or post facto (in days). Apparently, the requirement for system degradation notice in near real time is not of vital importance because only a handful of terrestrial operators expressed a need for it. In contrast, the need for notices in other time frames is shared by a larger number of operators. The following analysis is, therefore, confined to the latter's requirements. As Table 6-17 indicates, the modal leadtime requirement for short delay notices is 1 to 5 minutes for 39% terrestrial operators. The median leadtime is 10 minutes. On the other hand, the modal leadtime requirement for post processing is 1 day by 51% of respondents.

TABLE 6-17

LEADTIME REQUIREMENTS FOR NOTICES

LEADTIME	PERCENT	CUMULATIVE PERCENT
	Short Delay	
1 - 5 minutes	39	39
6 - 10	12	51
11 - 20	5	56
21 - 30	11	67
31 - 60	21	88
61 and above	12	100
		(17)
	Post Facto	
0 - 1 day	51	51
2 - 6 days	6	57
7 - 11	32	89
12 - 16	5	94
17 and above	6	100
		(17)

6.6 TERRESTRIAL RESPONDENT COMMENTS

At the end of the questionnaire, the respondents were invited to make any comments or provide any additional information on the RNSs, USCG, the survey, etc.

6.6.1 Respondent General Comments: About 75% of the respondents chose not to offer any comments. The following general comments were made by 25% of respondents: 8% lauded GPS, 3% opposed any intentional GPS accuracy degradation for civilian users. Another 3% lauded GPS but complained of high cost of receivers, 2% needed higher accuracy than proposed for PPS, another 2% lauded GPS and solicited higher accuracy than proposed for PPS, 7% proffered other comments which included asking for more information on federal RNS plan, offering an alternative to PPS, advocating general access to PPS and so on.

6.7 SOME CONCLUDING REMARKS

The USCG survey of terrestrial operators was aimed at finding RNS usage characteristics among terrestrial operators and their preferences and requirements. The findings have been discussed above. The survey also yielded critical sample data for the computation of mean characteristics and RNS user projections.

The terrestrial users of RNSs have a greater need for highly accurate navigation or location systems than any other group surveyed. Consequently, a substantial majority of terrestrial operators is not only aware of but many have used the satellite-based systems in their operations. However, most demand more accuracy than what is currently planned for GPS or other satellite-based systems. The following conclusions are drawn from the analysis of survey data above.

A. About 27% of terrestrial surveyors and mappers have not used any RNS in their operations.

B. Among terrestrial users of RNSs, nearly 83% report using GPS in their operations. In contrast, only 23% have employed

Transit and 35% LORAN-C. Note these statistics contain overlapping system users.

C. In comparison to LORAN-C, GPS and Transit have a higher incidence of use in field operations.

D. Among GPS and Transit users, each system is used primarily in the mapping and geodetic control operation. GPS is also used on a lesser scale in the cadastral operation and Transit in the vehicle position monitoring, rig positioning, seismic surveys and exploration operations.

E. A sizable number (40%) of terrestrial users of RNSs are not satisfied with the accuracies of current receivers.

F. Nearly all (97-98%) terrestrial users perceive benefits of using RNSs in the form of savings in time and indirect costs, but only two-thirds see benefit to be savings in fuel. The mean fuel savings due to the use of GPS, on the other hand, are marginal. The mean time savings due to GPS are 808 hours.

G. For current systems, the maximum transition period to GPS preferred by up to half the terrestrial users of RNSs is four years.

7. CONCLUSIONS

In undertaking the survey of radionavigation system users, the USCG was motivated by the desire to create a baseline of data on the civilian use of RNSs. The survey was targeted at three groups: state registered and Marine Safety Office (MSO) documented boat operators, merchant vessel operators, and terrestrial operators. The survey had the following objectives: (1) to gather empirical data on the federally operated electronic aids to navigation for USCG decision-making on the future mix of systems and services for the maritime and terrestrial users, (2) assess the incidence of ownership and usage of radionavigation equipment among maritime and terrestrial user communities, (3) evaluate the quality and benefits of services provided by the government, (4) determine accuracy requirements in different waters and operations, (5) gauge the general awareness and predisposition towards the proposed satellite-based systems and services and (6) determine user preferences for the transition period from current RNSs to GPS.

These objectives have been accomplished. The government has gathered empirical data on the civilian use of RNSs and has reported the findings above under the following headings: mean characteristics and receiver population projections, current radionavigation systems, proposed radionavigation systems, receiving systems, attributes and respondent comments. The data on incidence of ownership and usage has been collected for all RNSs and user groups. Similarly, data on user satisfaction and benefit ratings and actual amounts of savings have provided the necessary feedback on quality and benefits of services. The accuracy requirements have been determined for each survey group. Data on how all three survey groups are predisposed towards GPS and other satellite-based services have been gathered to gauge their receptivity towards the proposed systems. Finally, data showing preferences of all three survey groups for the transition periods from current systems to GPS have been collected to facilitate forthcoming decisions on the mix of radionavigation systems for the

near and long term.

The general conclusions that emerge from the survey of radionavigation system users are:

A. The primary radionavigation systems used by three survey groups are as follows: LORAN-C by small craft operators, Transit by merchant vessel operators and GPS by terrestrial operators.

B. Omega is the least used RNS among all three survey groups.

C. The selection of a primary system by each group is motivated by its accuracy requirements. These requirements have, in turn, shaped each group's predisposition towards the satellite-based systems. For instance, GPS is favored by fewer small craft operators than other groups because of the former group's least stringent accuracy requirements. On the other hand, the higher accuracy requirements of merchant vessel operators have produced a larger base of support among that group. The most stringent accuracy requirements of terrestrial operators have generated the largest percent of users of GPS among all three survey groups, even though for many users GPS accuracy falls short of their requirements.

D. The quality of service of current systems is adequate by user standards. Presumably, those RNS users who chronically experience signal problems with a system, switch to other more accurate and better coverage providing systems, and thus keep the statistics on the incidence of signal problems at depressed levels.

E. Users of RNSs perceive the benefits in terms of safety in navigation and savings in time, fuel and indirect costs. The actual savings, however, are quite marginal, except for fuel savings reported by the merchant vessel group which, relative to the scale and cost of operations, may not be substantial.

F. The level of awareness of GPS and other satellite-based services is very low among small craft operators, reflecting a general lack of interest in the system and services and also a failure on the part of the government to sponsor an educational

campaign to familiarize those operators with GPS.

G. For any current system, a maximum transition period of four years is acceptable to half the operators in all three groups surveyed.

H. The choice of sources by operators to get status information is governed by the criticality of such information in their operations. The more critical such information is the greater use a group makes of the printed information to avoid making mistakes. Most small craft operators are apparently not so particular about printed information because status information is not crucial to their boating, hence they derive their status information from marine radio broadcasts and radio communication with the local Coast Guard station. On the other hand, most merchant vessel operators consider status information to be critical to safe navigation; consequently, they rely on printed weekly or local Notices to Mariners. Similarly, a substantial number of terrestrial operators regard status information as crucial in their operations and, being computer literate, conveniently use electronic bulletin board services to generate hard copies as needed or rely on Air Force communications.

APPENDIX A: METHODOLOGY

A. METHODOLOGY

The section on survey methodology is intended to show the scientific principles followed in executing the Radionavigation System User Survey. The methodology is described under 7 headings: scope of the study, survey design, sample design, sample size, sample formulas, response rate and a word on sample balancing for population projections.

A.1 Scope of the Study

The Radionavigation System User Survey is limited in scope to the following populations:

1. Small craft registered with the maritime states and documented with the USCG Marine Safety Offices: includes pleasure, fishing, and small commercial craft but excludes dealer, demonstration, livery, political (state-owned), rental and other similar craft. The sample frame for each of the two groups of boaters was constructed as follows:

   A. State list of registered boats of 26 feet or more in Length Over All (LOA) in the following states: Alabama, Alaska, California, Connecticut, Delaware, District of Columbia, Florida, Georgia, Hawaii, Illinois, Indiana, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Texas, Virginia, Washington and Wisconsin. The inland states (except the Great Lakes states) and U.S. territories were excluded from this study because of low incidence of ownership of radionavigation equipment among them.

B. USCG MSO list of documented vessels of five or more net tons in the following documentation centers: Boston, Cleveland, Honolulu, Juneau, Los Angeles-Long Beach, Miami, New Orleans, New York, Norfolk, Philadelphia, Portland, St. Louis, San Francisco and Seattle.

2. Large commercial ships: includes U.S. privately-owned U.S. or foreign flagged vessels cataloged by Lloyd's Maritime Information Services Ltd., supplied on a magnetic tape in March 1988 as an updated version of Lloyd's List of Shipowners.

3. Terrestrial operators: includes USA-based members of the following professional organizations and participants in terrestrial symposia: American Congress on Surveying and Mapping (ACSM), International Association of Geophysical Contractors, Marine Surveying and Mapping Committee of ACSM, participants in the 1982 International Geodetic Symposium on Satellite Doppler Positioning, participants in the 1983 International Geodetic Symposium on Satellite Positioning and participants in the 1985 First International Symposium on Precise Positioning with the GPS. Note that the scope of the survey of terrestrial operators is confined to users of RNSs on the land mass (including land-locked lakes) and offshore waters. Since the base of operations of terrestrial operators could not be identified from the sampling frame, respondents were asked early on in the questionnaire itself to specify their base of operations. Operators falling outside the scope were asked to stop answering the questions further, and only respondents within the scope of the survey were asked to complete the questionnaire.

Any duplications in the lists were removed prior to selection of each sample.

A.2 <u>Survey Design</u>

For the Radionavigation System User Survey, the unit of sampling was: the owner of boat registered with a state registration authority, the owner of boat documented with the MSO, the parent company of merchant (private) vessel cataloged in the updated Lloyd's List of Shipowners, and terrestrial professional member or participant in the symposia mentioned above.

To compile the sampling frame of state registered craft, the states were requested to send their data on magnetic tapes or any other computer medium. Upon retrieving the data, records of boats of less than 26 feet were purged. The remaining records were then thoroughly shuffled to achieve a random distribution of boats by sorting on the boatowner last name, first name and middle name, since an alphabetical file bore no relation to any of the boat characteristics to be measured. Next, each file was sorted by boat usage and length into six strata: pleasure boats 26-39 feet, pleasure boats 40 feet or more, fishing boats 26-39 feet, fishing boats 40 feet or more, small commercial boats 26-39 feet, and small commercial boats 40 feet or more. The rationale for constructing a sampling frame of boats 26 feet or more in LOA was as follows:

1. Boats smaller than 16 feet are generally sailboats that operate almost exclusively in close proximity to shore, hence are not likely to carry radionavigation equipment.
2. Boats that are 16 to less than 22 feet operate only short distances from shore and for short periods, typically half a day or less, and avoid cruising in the night or during marginal weather, hence are not likely to carry radionavigation equipment.
3. Approximately 98% of the boats from 22 to less than 26 feet LOA are, by some industry estimates, without any radionavigation equipment. Their inclusion in the sample was considered cost prohibitive because a large volume of mailing would be required to generate a small number of returns possessing radionavigation equipment.

To generate a sampling frame of documented vessels, the MSOs were requested to send on diskettes (the only medium available on the standard USCG C^3 computers built by Convergent Technologies) their documented data files stored in accordance with the database scheme developed by Captain David L. Folsom of the Marine Safety Division of the First District, USCG. Although the database contained a field for vessel type, the data were for the most part missing; hence, documented vessels could not be stratified by vessel type. The owner name field was irregular because of missing data. Therefore, each MSO file was shuffled by sorting on the vessel name on the assumption that vessel names were not correlated with any of the characteristics to be measured in the survey. All records were included in the sampling frame of the documented vessels, since subsetting the database by length, unlike in the case of the state registration sampling frame, was not necessary. All documented vessels weighed at least five net tons which, of course, meant that they were at least 26 feet or more in LOA.

The sampling frame of U.S. company owned merchant vessels consisted of two files: U.S. flag and foreign flag vessels. Like the MSO files, each merchant vessel file was shuffled by vessel name. All government owned vessels, whether active or laid up, were purged from the U.S. flag file and not included in the sampling frame.

The terrestrial users sampling frame consisted of a miscellany of six name lists of surveyors and mappers. From hard copies, six computer files were created and shuffled by the last name, first name, and middle name. All names with foreign residences were purged from the files. Each list was considered a stratum.

A.3 Sample Design

The sampling technique employed for the Radionavigation System User Survey was stratified sampling. The universe was divided into finite populations of the sampling frames each of which, in turn, was divided into strata. A sample from each stratum was picked by

using the systematic sampling procedure.

A.4 Sample Size

The sample size was computed by using the following formula for proportions:

$$se_{\bar{y}} = \frac{(pq)^{1/2}}{\sqrt{n}}$$

and
$$n = \frac{pq}{se_{\bar{y}}^2}$$

where $se_{\bar{y}}$ is standard error of the mean, n = sample size, p is the proportion of responses, and q = 1 - p. The product pq is the variance of the sample mean.

The details of the algorithm used to compute the sample size are given elsewhere in the design study that was prepared for the OMB (Reference 2). A brief description is given here.

The sample size was computed by first choosing 100 as the minimum cell size (the smallest stratum) of a cross-tabulation matrix and working up to the total sample size. The following discussion illustrates the algorithm used for computing the sample size of state registered and documented vessels:

1. Estimated the ratios of RNS users among the boating public of 26 feet or more LOA for each class of boats for state registered and documented vessels: pleasure, fishing and small commercial. Thus,

   $$1 = r_{pl} + r_{fs} + r_{sc}$$

   where r_{pl} is the ratio of RNS users among pleasure boats, r_{fs} among fishing boats, and r_{sc} among small commercial boats.

2. Estimated the number of boats equipped with radionavigation equipment for each class of boats and then calculated the incidence of such equipment for the class by the following formula which, for illustration, shows the incidence for state registered small commercial boats:

$$_{st}I_{sc} = \frac{\text{small commercial craft with radionavigation equip.}}{\text{small commercial craft class total}}$$

where $_{st}I_{sc}$ is incidence of radionavigation equipment for small commercial class of boats for the state registered vessels.

3. Chose small commercial boats as the smallest analytical subgroup of a cross-tabulation matrix and assigned it 100 observations, the minimum cell size of the smallest stratum.
4. Assumed that 100 observations for the small commercial boats constituted 20% of the total sample for that class of boats. Accordingly, if 20% of the class sample was arbitrarily set to be 100 observations, then 100 percent gave the total sample size of that class as 500.
5. Computed the total design sample size of RNS users based on the following formula:

$$n_{RNS} = \frac{500}{r_{sc}}$$

where n_{RNS} is the total design sample size of RNS users.

6. Apportioned the sample size n_{RNS} to pleasure, fishing and small commercial boat classes by factoring in (i.e. multiplied with) the boat class ratios of step 1 above. The following formula illustrates the sample size of

small commercial boat class:

$$n_{sc} = n_{RNS} \quad x \quad r_{sc}$$

where n_{sc} is the design sample size of small commercial boat class.

7. Apportioned each boat class sample to two subclasses of state registered and documented boats by factoring in subclass ratios estimated from various independent sources. The following formula illustrates the sample size of the state registered subclass of small commercial boat class:

$${}_{st}n_{sc} = n_{sc} \quad x \quad {}_{st}r_{sc}$$

where ${}_{st}n_{sc}$ is the design subclass sample size of state registered small commercial boats, and ${}_{st}r_{sc}$ is the within-class ratio of state registered boats in the small commercial class.

8. Estimated the size of actual mail-outs by multiplying the design subclass sample size with an extra cushion factor of 15% and dividing with 70% expected rate of return. The following formula illustrates the computation of actual mail-outs for the state registered subclass sample in the small commercial boat class:

$$n_{st} = \frac{1.15 \ x \ {}_{st}n_{sc}}{{}_{st}I_{sc} \ x \ .7}$$

where n_{st} is the mail-out subclass sample of state registered boats, 1.15 is the 15 percent extra cushion factor, and .7 is the expected return rate of mailed questionnaires.

9. Used this algorithm to estimate the actual mail-outs for each subclass of boats--state registered and USCG documented boats--for pleasure, fishing and small

commercial classes. The sum of all subclass samples gave the total sample for the survey.

A.5 Sample Formulas

The estimator of the population mean, $\bar{y}$, is given by:

$$\bar{y} = \frac{1}{N} \sum_{i=1}^{H} N_i \, y_i$$

where N is the population total, H denotes the number of strata.

The estimated variance of $\bar{y}$ is given by:

$$\operatorname{var}(\bar{y}) = \sum_{i=1}^{H} \left[\frac{N_i^2}{N^2} \left(\frac{N_i - n_i}{N_i} \right) \frac{s_i^2}{n_i} \right]$$

where n_i is the sample of the ith stratum, and s_i is the sample variance of the ith stratum as shown below

$$s_i = \frac{\sum_{j=1}^{n_i} (y_{ij} - \bar{y}_i)^2}{n_i - 1}$$

The standard error of the sample mean $\bar{y}$ is given by:

$$se_{\bar{y}} = \sqrt{\operatorname{var}(\bar{y})}$$

The sample mean and variance are unbiased estimates of the population mean and variance because the sample size was fixed at n and, after shuffling each stratum list, a systematic sample was chosen which, in effect, is equivalent to a simple random sample of the stratum. (Kish, pp. 80-85, 117-118 and Cochran, pp. 212-214.)

A.6 Response Rate

Table A-1 shows the size of the sampling frame, sample drawn, returns and net returns (usables). The response rate of returns against the sample mail-outs as shown in the table above varies from 52% for the terrestrial users to 61% for the total registered and documented boats. The usables (returns less unusables) were in the range of 45% to 55% of the sample mail-outs, respectively.

TABLE A-1

RESPONSE RATE

SURVEY GROUP	FRAME	SAMPLE	RETURNS	USABLES
Registered Boats	290,087	5,687	3,369	2,989
Percent of Sample			(59%)	(52%)
Documented Boats	190,200	3,648	2,343	2,121
Percent of Sample			(64%)	(58%)
TOTAL	480,287	9,335	5,712	5,110
			(61%)	(55%)
Merchant U.S. Flag	626	167	103	95
Percent of Sample			(62%)	(57%)
Merchant Foreign Flag	622	165	83	75
Percent of Sample			(50%)	(45%)
TOTAL	1,248	332	186	170
			(56%)	(51%)
Terrestrial Users	1,183	235	122	106
Percent of Sample			(52%)	(45%)

A.7 A Word on Sample Balancing for Population Projections

Generally, when the sample is stratified, disproportionate returns from different strata can introduce biases that can seriously affect the accuracy of aggregate projections. Corrective weighting adjusts the returns to compensate for

disproportionalities in returns and achieves sample balancing. The objective of weighting is to make the returns of all strata reflective of the universe being measured. Once this objective has been achieved, the aggregate of a characteristic can be estimated by using the formula $N\bar{y}$ and its standard error by $Nse(\bar{y})$, if N, the characteristic population total, is known. (See Kish, pp. 433-434) In this study, N was known. However, in estimating the population totals and in computing the corresponding standard errors, the ratio p was substituted for $\bar{y}$, where p is the ratio of a characteristic that is present in the sample. The substitution of p for $\bar{y}$ is predicated on $p = \bar{y}$, a condition obtained whenever the presence of absence of a characteristic is enumerated by using the binary scheme of one for presence and zero for absence.

APPENDIX B: QUESTIONNAIRES

OMB No. 2115-0562

U.S. Coast Guard Radionavigation System User Survey

RECREATIONAL, FISHING, COMMERCIAL CRAFT QUESTIONNAIRE

INSTRUCTIONS:

1. If you own more than one craft, please answer the questionnaire for the craft identified on the mailing address.
2. Answer all applicable questions. Most questions require that you simply check a box.
3. Please return the completed questionnaire in the enclosed postage-paid, self-addressed, envelope within 10 days of receipt.

1. Please indicate in which waters you operate your craft, not counting occasional excursions or side trips. ***(Check all that apply)***

- ☐ Open ocean (50 and more nautical miles from shore)
- ☐ Coastal waters (less than 50 nautical miles from shore)
- ☐ Inland waters with access to coastal waters
- ☐ Lakes or river with no outlet to coastal waters
- ☐ Great Lakes

2. For what purpose, in which state waters, during what months, and what percent of total boating time, do you typically operate your craft? (Some of the purposes for which boaters operate their craft are: pleasure, commercial fishing, charter, ferry service, research, racing, etc.)

Purpose(s) Vessel is Used	States	Months	% of Total Boating Time
______	______	______	______
______	______	______	______
______	______	______	______

3. What is the length of your boat in feet? And to the best of your knowledge, what was the price paid and the year in which you acquired your craft?

Length: ______ ft. Price: $ ______ Year: ______

- ☐ Check here if craft was purchased new.

4. Which of the following methods do you employ to get status information on navigation aids such as radiobeacons, LORAN-C, buoys, fog signals, etc.? ***(Check all that apply)***

- ☐ Printed local Notices to Mariners
- ☐ Printed weekly Notices to Mariners
- ☐ Automated Notices to Mariners
- ☐ NAVTEX messages
- ☐ Electronic Bulletin Board Services
- ☐ Radio communications with local Coast Guard stations
- ☐ Marine radio broadcasts
- ☐ Other: *(Specify)* ______
- ☐ Do not get any status information

5. What percent of your total boating time do you use charts? ***(If you don't use any, enter zero)***

Paper charts: ______________ %

Electronic charts: ____________ %

6. For each radionavigation system listed below, indicate the number of receivers installed in your craft. ***(If you use more than one radionavigation system, check the system that you use most)***

Systems	Number of Receivers	System Most Used *(Check only one)*
Radiobeacons	______________	☐
OMEGA	______________	☐
TRANSIT (SATNAV)	______________	☐
LORAN-C	______________	☐
Other: (SPECIFY)		
________________________	______________	☐

☐ No radionavigation receiver installed in the craft

7. If you plan to buy a new radionavigation receiver in the next two years, please indicate what your new receiver will be.

☐ Radio Direction Finder (RDF)

☐ OMEGA

☐ TRANSIT

☐ LORAN-C

☐ Hybrid receiver (combination of two or more systems)

☐ Other: ________________________________

☐ Do not plan to buy in the next two years

IF YOUR CRAFT DOES NOT CARRY A RADIO DIRECTION FINDER, OMEGA, TRANSIT OR LORAN-C RADIONAVIGATION RECEIVER, SKIP TO QUESTION 18.

8. The radionavigation systems are generally used to get information on position, direction, range, time, and so on. How do you use the following radionavigation system(s)? ***(Check all that apply and also which usage you consider to be primary)***

Radiobeacons	Primary Usage *(Check one)*
☐ One bearing angle for homing or direction	☐
☐ Two or more bearing angles for a position fix	☐
☐ Other: *(Specify)* ______________________	☐

OMEGA	Primary Usage *(Check one)*
☐ Position	
Normal Mode:	☐
☐ Read phase differences from receiver and plot on chart to get position	
☐ Obtain position (latitude/longitude) from receiver display	
☐ Steer to a way point stored in receiver	
Rho Rho Mode:	☐
☐ Determine range by computing the signal's elapsed time between transmission and reception	
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________________	☐

TRANSIT	Primary Usage *(Check one)*
☐ Obtain position (latitude/longitude) from receiver display	☐
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________________	☐

LORAN-C	Primary Usage *(Check one)*
☐ Position	
Normal Mode:	☐
☐ Read Time Differences (TDs) from receiver and plot on chart to get position	
☐ Obtain position (latitude/longitude) from receiver display	
Repeatable Mode:	☐
☐ Compare TDs from receiver with previously measured values to return to a location	
☐ Steer to a way point stored in receiver	
Rho Rho Mode:	☐
☐ Determine range by computing the signal's elapsed time between transmission and reception	
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________________	☐

9. What percent of the time do you generally use the radionavigation system(s) in the different waters listed below? *(Answer all that apply)*

	Open Ocean	Coastal Waters	Inland Waters*	Lakes & Rivers**	Great Lakes
Radiobeacons	______ %	______ %	______ %	______ %	______ %
OMEGA	______	______	______	______	______
TRANSIT	______	______	______	______	______
LORAN-C	______	______	______	______	______

* — With access to coastal waters
** — Without outlet to coastal waters

10. Indicate whether or not the signal coverage provided by the radionavigation system(s) you use is sufficient for your safe and efficient navigation.

Radiobeacons: ☐ Yes ☐ No   OMEGA: ☐ Yes ☐ No
TRANSIT: ☐ Yes ☐ No   LORAN-C: ☐ Yes ☐ No

11. What percent of the time have you experienced the following problems while using the radionavigation system(s) listed below?

	Radiobeacons	OMEGA	TRANSIT	LORAN-C
No Signal Available	______ %	______ %	______ %	______ %
Weak Signal	______	______	______	______
Interference	______	______	______	______
Other: *(Specify)*				
______	______	______	______	______
______	______	______	______	______

12. How satisfied are you with the accuracy of the following radionavigation systems? *(Check all that apply)*

Systems	Very Satisfied	Somewhat Satisfied	Not at all Satisfied
Radiobeacons	☐	☐	☐
OMEGA	☐	☐	☐
TRANSIT	☐	☐	☐
LORAN-C	☐	☐	☐

13. How would you rate the benefits of using radionavigation system(s)?

	Very Important	Somewhat Important	Not at all Important
Improve navigational safety (avoid groundings and collisions)	☐	☐	☐
Save time	☐	☐	☐
Savings in fuel	☐	☐	☐
Savings in indirect costs	☐	☐	☐

14. Please give your best estimate of your yearly savings attributable to the use of radionavigation system(s). ***(If none, enter zero)***

	Radiobeacons	OMEGA	TRANSIT	LORAN-C
Fuel savings (gallons)	______ gals	______ gals	______ gals	______ gals
Time savings (hours)	______ hrs	______ hrs	______ hrs	______ hrs
Other: *(Specify)*				
______________	______	______	______	______
______________	______	______	______	______

15. When transiting the waters as specified below, what level of accuracy do you need to meet your requirements? ***(Fill in all that apply and indicate each unit of measurement you use, e.g., nautical miles, meters, yards, etc.)***

Open Ocean	Coastal Waters	Inland Waters/Rivers*	Lakes & Rivers**	Great Lakes
________	________	________	________	________

* — With access to coastal waters
** — Without outlet to coastal waters

16. Does your current receiver(s) meet all your accuracy requirements?

☐ Yes

☐ No → What is the highest amount you are willing to spend on purchasing a radionavigation receiver that will meet all your requirements?

$ ________________

17. In harbor approaches and inland waterways, LORAN-C accuracy can be improved 40 to 60 percent by using differential corrections. This technique involves calculating the error of the LORAN-C signal through the use of reference stations and broadcasting a correction by radio. By applying the correction, generally, an accuracy of less than 20 meters can be obtained by properly-equipped users within the reference stations' coverage area (nominally within a 50 mile radius). If this type of service was provided by the Government at no cost, please indicate whether you would:

☐ Purchase a differential receiver.

☐ Modify an installed LORAN-C receiver to accept differential corrections.

☐ Be unlikely to use LORAN-C differential corrections.

18. The Defense Department's Global Positioning System (GPS) is a satellite-based radio positioning, navigation, and timing system. GPS is in the final stages of testing and is available for limited use to the general boating public. It is scheduled to be fully operational in the early 1990s. It will provide worldwide coverage and essentially a continuous fix rate. Please specify your level of experience and familiarity with GPS.

☐ No experience or familiarity

☐ No experience, but informed through books, publications, meetings, etc.

☐ Some operational experience and familiarity (through receiver operation, processing GPS data, etc.)

19. For the general boating public, GPS will provide an accuracy of 100 meters. It will give a continuous fix rate at this level of accuracy in all waters. Will this accuracy benefit you?

☐ Yes → What is the highest amount you are willing to spend on a GPS receiver? $ ____________

☐ No

20. Using the same technique as in differential LORAN-C (Reference Question 17), the differential GPS will have an improved accuracy of less than 20 meters and an extended coverage area to 100-mile radius. If this type of service was provided by the Government at no cost, please indicate whether you would:

☐ Purchase a differential GPS receiver. → What is the highest amount you are willing to spend on a differential GPS receiver? $ ____________

☐ Modify installed GPS receiver to accept differential corrections.

☐ Be unlikely to use GPS differential corrections.

21. GPS will also have, for military applications, a Precise Positioning Service (PPS) with an accuracy of 20 meters or less. This service could be made available for a fee to the general public only if they: (a) have a valid need for such an accuracy, (b) have exhausted alternative sources, and (c) can give evidence that its use will be in the US national interest. Would you require access to PPS?

☐ Yes ☐ No ☐ Not sure

22. If GPS was to replace the following radionavigation systems, how many years would you prefer to have the current systems remain available after GPS becomes fully operational (i.e., How long a transition period would you prefer)?

	Radiobeacons	OMEGA	TRANSIT	LORAN-C
Number of Years:	________	________	________	________

23. As listed below, there are also several commercial satellite-based radiolocation systems going into service in the near future. How familiar are you with these systems? *(Please indicate any other systems not listed)*

	Very Familiar	Somewhat Familiar	Not Familiar
GEOSTAR	☐	☐	☐
STARFIX	☐	☐	☐
STARFIND	☐	☐	☐
Other: *(Specify)*			
________	☐	☐	☐
________	☐	☐	☐

24. Shown below are the accuracy figures claimed by other commercial radiolocation systems. Please indicate whether or not the planned accuracy of each system would satisfy your needs and the highest amount you are willing to spend on a receiver for each system. *(Please indicate other system(s) you are familiar with that are not listed)*

	Accuracy	Yes	No	Highest Amount
GEOSTAR	100 meters	☐	☐	$ ________
STARFIX	10 meters*	☐	☐	$ ________
STARFIND	6 meters**	☐	☐	$ ________
Other: *(Specify)*				
________	________	☐	☐	$ ________

* — valid for speeds less than 10 knots
** — valid for speeds less than 5 knots

Note: The statistical basis used for all navigation accuracy figures indicated in this questionnaire is 2dRMS (distance Root Mean Square) at 95% level of confidence.

THE FOLLOWING QUESTION WILL PROVIDE IMPORTANT INFORMATION ON YOUR CRAFT'S ELECTRONIC EQUIPMENT PACKAGE.

25. Please check the electronic equipment (other than radionavigation receivers) used on board your craft. *(Check all that apply)*

☐ Depth Sounder/Sonar

☐ Radar

☐ Communications equipment

	VHF-FM	**HF-SSB**	**Other: *(Specify)*** ________________
Receiver	☐	☐	☐
Transmitter	☐	☐	☐

☐ Television

☐ Video cassette recorder (VCR)

☐ Personal computer

☐ Audio tape recorder

☐ Other: *(Specify)* ______________________________

FINALLY, THE FOLLOWING SPACE HAS BEEN LEFT FOR YOUR COMMENTS, OR ANY ADDITIONAL INFORMATION YOU MAY WISH TO GIVE.

26.

END OF SURVEY.

PLEASE RETURN THE COMPLETED QUESTIONNAIRE IN THE ENCLOSED POSTAGE-PAID, SELF-ADDRESSED ENVELOPE. THANK YOU VERY MUCH FOR YOUR COOPERATION.

OMB No. 2115-0562

U.S. Coast Guard Radionavigation System User Survey

MERCHANT SHIPS QUESTIONNAIRE

INSTRUCTIONS:

1. If you own more than one ship, please answer the questionnaire for the ship identified on the mailing address.
2. Answer all applicable questions. Most questions require that you simply check a box.
3. Please return the completed questionnaire in the enclosed postage-paid, self-addressed envelope within 10 days of receipt.

1. For each radionavigation system listed below, indicate the number of receivers installed in your merchant ship. ***(If you use more than one radionavigation system, check the system that you use most)***

Systems	**Number of Receivers**	**System Most Used** ***(Check only one)***
Radiobeacons	________	☐
OMEGA	________	☐
TRANSIT (SATNAV)	________	☐
LORAN-C	________	☐
Other: (SPECIFY)		
____________	________	☐

2. Please check the electronic equipment (other than radionavigation receivers) used on board your merchant ship. ***(Check all that apply)***

☐ Depth Sounder/Sonar

☐ Radar

☐ Communications equipment

	VHF-FM	**HF-SSB**	**Satellite**	**Other:** ***(Specify)*** ________
Receiver	☐	☐	☐	☐
Transmitter	☐	☐	☐	☐

☐ Television

☐ Video cassette recorder (VCR)

☐ Personal computer

☐ Audio tape recorder

☐ Other: *(Specify)* ____________________

3. Which of the following methods do you employ to get status information on navigation aids such as radiobeacons, LORAN-C, buoys, fog signals, etc.? *(Check all that apply)*

- ☐ Printed local Notices to Mariners
- ☐ Printed weekly Notices to Mariners
- ☐ Automated Notices to Mariners
- ☐ NAVTEX messages
- ☐ Electronic Bulletin Board Services
- ☐ Radio communications with local Coast Guard stations
- ☐ Marine radio broadcasts
- ☐ Other: *(Specify)* ______________
- ☐ Do not get any status information

4. The radionavigation systems are generally used to get information on position, direction, range, time, and so on. How do you use the following radionavigation system(s)? *(Check all that apply and also which usage you consider to be primary)*

Radiobeacons	**Primary Usage *(Check one)***
☐ One bearing angle for homing or direction	☐
☐ Two or more bearing angles for a position fix	☐
☐ Other: *(Specify)* ______________	☐

OMEGA	**Primary Usage *(Check one)***
☐ Position	
Normal Mode:	☐
☐ Read phase differences from receiver and plot on chart to get position	
☐ Obtain position (latitude/longitude) from receiver display	
☐ Steer to a way point stored in receiver	
Rho Rho Mode:	☐
☐ Determine range by computing the signal's elapsed time between transmission and reception	
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________	☐

TRANSIT (SATNAV)	**Primary Usage** ***(Check one)***
☐ Obtain position (latitude/longitude) from receiver display	☐
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________________	☐

LORAN-C	**Primary Usage** ***(Check one)***
☐ Position	
Normal Mode:	☐
☐ Read Time Differences (TDs) from receiver and plot on chart to get position	
☐ Obtain position (latitude/longitude) from receiver display	
Repeatable Mode:	☐
☐ Compare TDs from receiver with previously measured values to return to a location	
☐ Steer to a way point stored in receiver	
Rho Rho Mode:	☐
☐ Determine range by computing the signal's elapsed time between transmission and reception	
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________________	☐

5. What percent of the time do you generally use the radionavigation system(s) in the different waters listed below? *(Answer all that apply)*

	Open Ocean*	Coastal Waters**	Inland Waters	Great Lakes
Radiobeacons	______ %	______ %	______ %	______ %
OMEGA	______	______	______	______
TRANSIT	______	______	______	______
LORAN-C	______	______	______	______

* — 50 and more nautical miles from shore
** — Less than 50 nautical miles from shore

6. Indicate whether or not the signal coverage provided by the radionavigation system(s) you use is sufficient for your safe and efficient navigation.

Radiobeacons: ☐ Yes ☐ No OMEGA: ☐ Yes ☐ No
TRANSIT: ☐ Yes ☐ No LORAN-C: ☐ Yes ☐ No

7. What percent of the time have you experienced the following problems while using the radionavigation system(s) listed below?

	Radiobeacons	OMEGA	TRANSIT	LORAN-C
No Signal Available	______ %	______ %	______ %	______ %
Weak Signal	______	______	______	______
Interference	______	______	______	______
Other: *(Specify)*				
______	______	______	______	______
______	______	______	______	______

8. How satisfied are you with the accuracy of the following radionavigation systems? *(Check all that apply)*

Systems	Very Satisfied	Somewhat Satisfied	Not at all Satisfied
Radiobeacons	☐	☐	☐
OMEGA	☐	☐	☐
TRANSIT	☐	☐	☐
LORAN-C	☐	☐	☐

9. How would you rate the benefits of using radionavigation system(s)?

	Very Important	Somewhat Important	Not at all Important
Improve navigational safety (avoid groundings and collisions)	☐	☐	☐
Save time	☐	☐	☐
Savings in fuel	☐	☐	☐
Savings in indirect costs	☐	☐	☐

10. Please give your best estimate of your yearly savings attributable to the use of radionavigation system(s). ***(If none, enter zero)***

	Radiobeacons	OMEGA	TRANSIT	LORAN-C
Fuel savings (gallons)	______ gals	______ gals	______ gals	______ gals
Time savings (hours)	______ hrs	______ hrs	______ hrs	______ hrs
Other: *(Specify)*				
____________	______	______	______	______
____________	______	______	______	______

11. When transiting the waters as specified below, what level of accuracy do you need to meet your requirements? ***(Fill in all that apply and indicate each unit of measurement you use, e.g., nautical miles, meters, yards, etc.)***

Open Ocean*	Coastal Waters**	Inland Waters	Great Lakes
____________	____________	____________	____________

* — 50 and more nautical miles from shore access to coastal waters

** — Less than 50 nautical miles from shore

12. Does your current receiver(s) meet all your accuracy requirements?

☐ Yes

☐ No ⟶ What is the highest amount you are willing to spend on purchasing a radio-navigation receiver that will meet all your requirements?

$ ____________________

13. If you plan to buy a new radionavigation receiver in the next two years, please indicate what your new receiver will be.

- ☐ Radiobeacons
- ☐ OMEGA
- ☐ TRANSIT
- ☐ LORAN-C
- ☐ Hybrid receiver (combination of two or more systems)
- ☐ Other: ______________________________
- ☐ Do not plan to buy in the next two years.

14. In harbor approaches and inland waterways, LORAN-C accuracy can be improved 40 to 60 percent by using differential corrections. This technique involves calculating the error of the LORAN-C signal through the use of reference stations and broadcasting a correction by radio. By applying the correction, generally, an accuracy of less than 20 meters can be obtained by properly-equipped users within the reference stations' coverage area (nominally within a 50 mile radius). If this type of service was provided by the Government at no cost, please indicate whether you *would*:

- ☐ Purchase a differential receiver.
- ☐ Modify an installed LORAN-C receiver to accept differential corrections.
- ☐ Be unlikely to use LORAN-C differential corrections.

15. The Defense Department's Global Positioning System (GPS) is a satellite-based radio positioning, navigation, and timing system. GPS is in the final stages of testing and is available for limited use to the merchant marine community. It is scheduled to be fully operational in the early 1990s. It will provide worldwide coverage and essentially a *continuous* fix rate. Please specify your level of experience and familiarity with GPS.

- ☐ No experience or familiarity
- ☐ No experience, but informed through books, publications, meetings, etc.
- ☐ Some operational experience and familiarity (through receiver operation, processing GPS data, etc.)

16. For the general marine community, GPS will provide an accuracy of 100 meters. It will give a continuous fix rate at this level of accuracy in <u>all</u> waters. Will this accuracy benefit you?

- ☐ Yes ⟶ What is the highest amount you are willing to spend on a GPS receiver? $ ______________
- ☐ No

17. Using the same technique as in differential LORAN-C (Reference Question 14), the differential GPS will have an improved accuracy of less than 20 meters and an extended coverage area to 100-mile radius. If this type of service was provided by the Government at no cost, please indicate whether you would:

☐ Purchase a differential GPS receiver. → What is the highest amount you are willing to spend on a differential GPS receiver?
$ ____________________

☐ Modify installed GPS receiver to accept differential corrections.

☐ Be unlikely to use GPS differential corrections.

18. GPS will also have, for military applications, a Precise Positioning Service (PPS) with an accuracy of 20 meters or less. This service could be made available for a fee to the merchant marine community if they: (a) have a valid need for such an accuracy, (b) have exhausted alternative sources, and (c) can give evidence that its use will be in the US national interest. Would you require access to PPS?

☐ Yes ☐ No ☐ Not sure

19. If GPS was to replace the following radionavigation systems, how many years would you prefer to have the current systems remain available after GPS becomes fully operational (i.e., How long a transition period would you prefer)?

	Radiobeacons	**OMEGA**	**TRANSIT**	**LORAN-C**
Number of Years:	________	________	________	________

20. As listed below, there are also several commercial satellite-based radiolocation systems going into service in the near future. How familiar are you with these systems? *(Please indicate any other systems not listed)*

	Very Familiar	**Somewhat Familiar**	**Not Familiar**
GEOSTAR	☐	☐	☐
STARFIX	☐	☐	☐
STARFIND	☐	☐	☐
Other: *(Specify)*			
____________________	☐	☐	☐
____________________	☐	☐	☐

21. Shown below are the accuracy figures claimed by other commercial radiolocation systems. Please indicate whether or not the planned accuracy of each system would satisfy your needs and the highest amount you are willing to spend on a receiver for each system. *(Please indicate other system(s) you are familiar with that are not listed)*

	Accuracy	Yes	No	Highest Amount
GEOSTAR	100 meters	☐	☐	$ ________
STARFIX	10 meters*	☐	☐	$ ________
STARFIND	6 meters**	☐	☐	$ ________
Other: *(Specify)*				
________	____	☐	☐	$ ________

* — valid for speeds less than 10 knots
** — valid for speeds less than 5 knots

Note: The statistical basis used for all navigation accuracy figures indicated in this questionnaire is 2dRMS (distance Root Mean Square) at 95% level of confidence.

FINALLY, THE FOLLOWING SPACE HAS BEEN LEFT FOR YOUR COMMENTS, OR ANY ADDITIONAL INFORMATION YOU MAY WISH TO GIVE.

22.

END OF SURVEY.

PLEASE RETURN THE COMPLETED QUESTIONNAIRE IN THE ENCLOSED POSTAGE-PAID, SELF-ADDRESSED, ENVELOPE. THANK YOU VERY MUCH FOR YOUR COOPERATION.

OMB No. 2115-0562

U.S. Coast Guard Radionavigation System User Survey

TERRESTRIAL USERS QUESTIONNAIRE

INSTRUCTIONS:

1. Answer all applicable questions. Most questions require that you simply check a box.
2. Please return the completed questionnaire in the enclosed postage-paid, self-addressed envelope within 10 days of receipt.

1. Please indicate the radionavigation/radiolocation receivers you use for land positioning/navigation. ***(If you use more than one type of receiver, check the type you use most)***

	Type Most Used ***(Check only one)***
☐ OMEGA	☐
☐ TRANSIT (SATNAV)	☐
☐ LORAN-C	☐
☐ Global Positioning System (GPS)	☐
☐ Other: *(Specify)*	
________________________	☐
________________________	☐
☐ No radionavigation/radiolocation receiver used	

2. If you plan to buy a new radionavigation/radiolocation receiver in the next two years, please indicate what your new receiver will be.

- ☐ OMEGA
- ☐ TRANSIT (SATNAV)
- ☐ LORAN-C
- ☐ Global Positioning System (GPS)
- ☐ Hybrid Receiver (combination of two or more systems)
- ☐ Other: *(Specify)* ________________________
- ☐ Do not plan to buy in the next two years.

IF YOU DO NOT USE AN OMEGA, TRANSIT, LORAN-C, OR GPS RECEIVER, SKIP TO QUESTION 19.

3. Do you use your receiver(s) primarily on land, off-shore, or in ocean waters?

- ☐ Land (including land-locked lakes)
- ☐ Off-shore exploration
- ☐ Ocean waters
- ☐ Neither of the above

IF YOU CHECKED OCEAN WATERS OR NEITHER OF THE ABOVE, STOP HERE. WE ARE INTERESTED AT THIS TIME IN POLLING LAND AND OFF-SHORE USERS ONLY. PLEASE RETURN THIS QUESTIONNAIRE IN THE ENCLOSED POSTAGE-PAID, SELF-ADDRESSED ENVELOPE. THANK YOU VERY MUCH FOR YOUR COOPERATION.

4. How do you use the following radionavigation system(s) in your operations? *(Check all that apply and also which usage you consider to be primary)*

OMEGA	**Primary Usage *(Check one)***
☐ Position	
Normal Mode:	☐
☐ Read phase differences from receiver and plot on chart to get position	
☐ Obtain position (latitude/longitude) from receiver display	
☐ Get to a way point stored in receiver	
Rho Rho Mode:	☐
☐ Determine range by computing the signal's elapsed time between transmission and reception	
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________	☐

TRANSIT	**Primary Usage *(Check one)***
☐ Obtain position (latitude/longitude) from receiver display	☐
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________	☐

LORAN-C	Primary Usage *(Check one)*
☐ Position	
Normal Mode:	☐
☐ Read Time Differences (TDs) from receiver and plot on chart to get position	
☐ Obtain position (latitude/longitude) from receiver display	
Repeatable Mode:	☐
☐ Compare TDs from receiver with previously measured values to return to a location	
☐ Get to a way point stored in receiver	
Rho Rho Mode:	☐
☐ Determine range by computing the signal's elapsed time between transmission and reception	
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________	☐

GLOBAL POSITIONING SYSTEM	Primary Usage *(Check one)*
☐ Obtain position (latitude/longitude) from receiver display	☐
☐ Get to a way point stored in receiver	☐
☐ Precise time and time interval (PTTI)	☐
☐ Other: *(Specify)* ______________	☐

5. Please specify the states in which you use your receiver(s) regularly for navigation/positioning.

Receivers	States
OMEGA	______________
TRANSIT	______________
LORAN-C	______________
GPS	______________

6. For the applications listed below, please check the type of receiver(s) you use. ***(Check all that apply)***

Applications	OMEGA	TRANSIT	LORAN-C	GPS
Dredging	☐	☐	☐	☐
Pipe Laying	☐	☐	☐	☐
Cadastral	☐	☐	☐	☐
Mapping and geodetic control	☐	☐	☐	☐
Construction	☐	☐	☐	☐
Rig positioning	☐	☐	☐	☐
Seismic surveys	☐	☐	☐	☐
Mining	☐	☐	☐	☐
Exploration	☐	☐	☐	☐
Vehicle position monitoring	☐	☐	☐	☐
Other: *(Specify)*				
______________________	☐	☐	☐	☐
______________________	☐	☐	☐	☐

7. In your total field operations, what percent of the time do you use the radionavigation/radiolocation receiver(s) listed below?

OMEGA __________ %   TRANSIT __________ %

LORAN-C __________   GPS __________

8. Which of the following methods do you employ to get status information on radionavigation systems? ***(Check all that apply)***

- ☐ Printed Local Notices to Mariners
- ☐ Automated Notices to Mariners
- ☐ Printed Weekly Notices to Mariners
- ☐ NAVTEX messages
- ☐ Electronic Bulletin Board Services
- ☐ Radio communications with local Coast Guard stations
- ☐ Marine radio broadcasts
- ☐ Other: *(Specify)* ______________________
- ☐ Do not get any status information

9. How much lead time do you need for notice advisories on the operational status of radionavigation system(s) you use? Please indicate the lead time in hours, days, or weeks.

Lead time: ______________________ hours/days/weeks

10. Please indicate how soon you need notification of any degradation in the radionavigation system(s) you use.

Near real time (within one minute) ______________ seconds

Short delay ______________ minutes

Post facto (post processing) ______________ days

11. Indicate whether or not the coverage provided by the radionavigation system(s)* you use is sufficient for your operations.

OMEGA: ☐ Yes ☐ No TRANSIT: ☐ Yes ☐ No

LORAN-C: ☐ Yes ☐ No

* GPS is excluded because the present constellaton is for tests only.

12. What percent of the time have you experienced the following problems while using the radionavigation system(s)* listed below?

	OMEGA	TRANSIT	LORAN-C
No Signal Available	______ %	______ %	______ %
Weak Signal	______	______	______
Interference	______	______	______
Inaccurate Readings	______	______	______
Other: *(Specify)*			
______	______	______	______
______	______	______	______

* GPS is excluded because the present constellation is for tests only.

13. How satisfied are you with the accuracy of the following radionavigation system(s)? *(Check all that apply)*

Systems	**Very Satisfied**	**Somewhat Satisfied**	**Not at all Satisfied**
OMEGA	☐	☐	☐
TRANSIT	☐	☐	☐
LORAN-C	☐	☐	☐
GPS	☐	☐	☐

14. How do you rate the benefits of using radionavigation system(s)?

	Very Important	**Somewhat Important**	**Not at all Important**
Save time	☐	☐	☐
Savings in fuel	☐	☐	☐
Savings in indirect costs	☐	☐	☐

15. Please give your best estimate of your yearly savings attributable to the use of radionavigation system(s). *(If none, enter zero)*

	OMEGA	TRANSIT	LORAN-C	GPS
Fuel savings (gallons)	______ gals	______ gals	______ gals	______ gals
Time savings (hours)	______ hrs	______ hrs	______ hrs	______ hrs
Other: *(Specify)*				
______	______	______	______	______
______	______	______	______	______

16. For the applications listed below, what degree of navigation/positioning accuracy would satisfy your requirements? Please indicate the unit of measurement (feet, yards, meters, etc.)

Applications	**Accuracy**
Dredging	______________
Pipe laying	______________
Cadastral	______________
Mapping and geodetic control	______________
Construction	______________
Rig Positioning	______________
Seismic surveys	______________
Mining	______________
Exploration	______________
Vehicle position monitoring	______________
Other: *(Specify)*	______________
______________	______________
______________	______________

17. Does your current receiver(s) meet all your accuracy requirements?

☐ Yes

☐ No → What is the highest amount you are willing to spend on purchasing a radio-navigation receiver that will meet all your requirements?

$ ______________

18. LORAN-C accuracy can be improved 40 to 60 percent by using differential corrections. This technique involves calculating the error of the LORAN-C signal through the use of reference stations and broadcasting a correction by radio. By applying the correction, generally, an accuracy of less than 20 meters can be obtained by properly-equipped users within the reference stations' coverage area (nominally within a 50 mile radius). If this type of service was provided by the Government at no cost, please indicate whether you would:

☐ Purchase a differential receiver.

☐ Modify an existing LORAN-C receiver to accept differential corrections.

☐ Be unlikely to use LORAN-C differential corrections.

19. The Defense Department's Global Positioning System (GPS) is a satellite-based radio positioning, navigation, and timing system. GPS is in the final stages of testing and is available for limited use by the general public. It is scheduled to be fully operational in the early 1990s. It will provide worldwide coverage and essentially a continuous fix rate. Please specify your level of experience and familiarity with GPS.

☐ No experience or familiarity

☐ No experience, but informed through books, publications, meetings, etc.

☐ Some operational experience and familiarity (through receiver operation, processing GPS data, etc.)

20. For the general public, GPS will provide an accuracy of 100 meters. It will give a continuous fix rate at this level of accuracy in all terrain and waters. Will this accuracy benefit you?

☐ Yes → What is the highest amount you are willing to spend on a GPS receiver? $ ____________

☐ No

21. Using the same technique as in differential LORAN-C (Reference Question 18), the differential GPS will have an improved accuracy of less than 20 meters and an extended coverage area to 100-mile radius. If this type of service was provided by the Government at no cost, please indicate whether you would:

☐ Purchase a differential GPS receiver. → What is the highest amount you are willing to spend on a differential GPS receiver? $ ____________

☐ Modify existing GPS receiver to accept differential corrections.

☐ Be unlikely to use GPS differential corrections.

22. GPS will also have, for military applications, a Precise Positioning Service (PPS) with an accuracy of 20 meters or less. This service could be made available for a fee to the general public only if they: (a) have a valid need for such an accuracy, (b) have exhausted alternative sources, and (c) can give evidence that its use will be in the US national interest. Would you require access to PPS?

☐ Yes ☐ No ☐ Not sure

23. If GPS was to replace the following radionavigation systems, how many years would you prefer to have the current systems remain available after GPS becomes fully operational (i.e., How long a transition period would you prefer)?

	Radiobeacons	**OMEGA**	**TRANSIT**	**LORAN-C**
Number of Years:	______	______	______	______

24. As listed below, there are also several commercial satellite-based radiolocation systems going into service in the near future. How familiar are you with these systems? *(Please indicate any other systems not listed)*

	Very Familiar	**Somewhat Familiar**	**Not Familiar**
GEOSTAR	☐	☐	☐
STARFIX	☐	☐	☐
STARFIND	☐	☐	☐
Other: *(Specify)*			
______________	☐	☐	☐
______________	☐	☐	☐

25. Shown below are the accuracy figures claimed by other commercial radiolocation systems. Please indicate whether or not the planned accuracy of each system would satisfy your needs and the highest amount you are willing to spend on a receiver for each system. ***(Please indicate other system(s) you are familiar with that are not listed)***

	Accuracy	Yes	No	Highest Amount
GEOSTAR	100 meters	☐	☐	$ ________
STARFIX	10 meters*	☐	☐	$ ________
STARFIND	6 meters**	☐	☐	$ ________
Other: *(Specify)*				
________	________	☐	☐	$ ________

* — valid for speeds less than 10 knots

** — valid for speeds less than 5 knots

Note: The statistical basis used for all navigation accuracy figures indicated in this questionnaire is 2dRMS (distance Root Mean Square) at 95% level of confidence.

FINALLY, THE FOLLOWING SPACE HAS BEEN LEFT FOR YOUR COMMENTS, OR ANY ADDITIONAL INFORMATION YOU MAY WISH TO GIVE.

26.

END OF SURVEY.

PLEASE RETURN THE COMPLETED QUESTIONNAIRE IN THE ENCLOSED POSTAGE-PAID, SELF-ADDRESSED, ENVELOPE. THANK YOU VERY MUCH FOR YOUR COOPERATION.

REFERENCES

1. William G. Cochran. Sampling Techniques, Third Edition, New York: John Wiley & Sons, 1977.
2. Input Output Computer Services, Inc. Radionavigation Users Survey; Supporting Statement for OMB Review, Prepared for U.S. Department of Transportation, Transportation Systems Center, Cambridge, MA, April 1987.
3. Leslie Kish. Survey Sampling, New York: John Wiley & Sons, 1965.

80 copies